TEMPLATES IN EARLY PHONOLOGICAL DEVELOPMENT

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For

Kyle, who showed more patience than a Chicago Blackhawk
and all love always

Djuna, who provided a mass of fascinating data
and approved my schematic networks

Doreen, who slept on my chest
while I wrote

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Child language data are notoriously noisy. Children may produce several phonetic variants for a given word or use the same forms for several different words. As such, child data are characterized by little apparent systematicity. Competing theories have arisen to account for a range of problematic phenomena, but each has struggled to relate child and adult phonology. Pulling together interdisciplinary findings, this research crafts a usage-based theory of early phonological acquisition by uniting a whole-word approach to representation, schema theory, and dynamic systems theory. As an investigation of developing representational processes, this study examines production data collected at the onset of word production from four children acquiring American English.

Cross-linguistic evidence for the primacy of phonological representation shaped by the whole word (i.e., template) in early acquisition has been reported, but questions about template function motivate closer scrutiny. As a supporting framework, schema theory conceives of schematic categories mapped hierarchically, defined by varying degrees of abstraction. Dynamic systems theory serves as a connecting framework, capable of describing the tenuous stability of phonological behaviors developing in continuous time. Two major analytical steps comprise this research. The first entails analysis of each child's lexical development in connection with templatic behavior. Analysis reveals points of prominent template use in relationship with other linguistic changes. The second analytical step places templatic patterns within schematic networks, facilitating a visual depiction of emerging representation as a phonological system gains in complexity.

The union of the templatic approach with schema theory and dynamic systems theory offers a novel approach to early acquisition data. This research importantly contributes to our limited knowledge of early phonological acquisition processes. It highlights idiosyncrasy in developmental paths across children and also the importance of conditions present at the inception of a phonological system for being able to see how each path takes shape.

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Chapter 1: Introduction

1.1 Background and preview of the dissertation

Child language data is notoriously noisy. Children begin producing words around one year of age (Clark, 1993; de Villiers & de Villiers, 1978; Dromi, 1987; Gerken, 2008; Tomasello, 2005), and phonological data collected during the first year of word production is characterized by little apparent systematicity and is, thus, challenging to put to coherent analysis. In some cases, there is little segment-to-segment correspondence between child forms and adult words, and processes rarely seen in adult phonology are commonly observed in child speech (e.g., velar fronting, metathesis, consonant harmony). Because these phenomena are so difficult to integrate into a coherent theory of language that also accounts for adult linguistic phenomena, divergent theories concerning the processes of acquisition have arisen. Traditional nativist theoretical frameworks claim that linguistic structures of some kind must be innate in order for a complex linguistic system shared across speakers to be possible. Emergentist theories, in contrast, claim that linguistic categories initially form by way of specific usage events subject to general cognitive processes. This chapter contextualizes an argument for an emergent theory of language by presenting a range of theories of phonological acquisition.

Pulling together interdisciplinary findings, this dissertation crafts a usage-based theory of early phonological acquisition uniting a whole-word approach to representation, schema theory, and dynamic systems theory. This work targets a narrowly defined period at the onset of word production and examines the production data of four American

English-acquiring children. This period is crucial for gaining a deeper understanding of phonological acquisition processes precisely because the data is noisy. More specifically, these data reveal the first phonetic realizations of phonological knowledge and, as a consequence, offer important insight into the characterization of representation. At its core, this dissertation is an investigation of developing phonological processes in early language acquisition. It is crucial that, in this work, representation be understood as exactly that—as processes. The term "representation" will be used throughout as a means of convenience, but because this work crafts a theory drawing from the concepts found in dynamic systems theory, it is important to remember that when the tem "representation" is used we should think of continuously interacting sets of processes.

The templatic approach to acquisition addresses early-developing phonological representation. The framework gives primacy to phonological representation shaped by the whole word (Vihman & Croft, 2007), but has not clearly defined the intricacies of template function. In order to bring nuance to this approach, the current work places the templatic approach within schema theory, looking to the tools of cognitive grammar (Langacker, 1987) and appealing to what is known about cognition. As such, the perspective taken here assumes a usage-based model of language that describes representation in hierarchical networks built on degrees of variable abstraction. In view of representation as sets of processes, we should think of representational degrees of abstraction as processes in use at different rates of productivity by a given speaker. Dynamic systems theory (Thelen & Smith, 1994) necessarily integrates this framework because (1) its properties of self-organization and embodiment are capable of explaining how the cognition involved with an emerging phonological system arranges itself from phonetic prelinguistic beginnings; and (2) it incorporates the important notion of time, allowing for the realistic interpretation of speech data as they occur in continuous time. In order to contextualize the choice to weave together templatic theory, dynamic systems theory, and schema theory, this chapter provides an overview of how variants of nativist and emergentist theoretical frameworks aim to capture the processes of language acquisition.

At the center of acquisition research, whichever theoretical framework is employed, is an argument about the nature of mental representation. Theories differ concerning how static or fluid representation is considered to be, how many levels of representation should be recognized, and whether or not there are levels of representation. Section 1.3 focuses on representational models of phonological acquisition, and four points are clarified regarding how the term representation is used in the present research: (1) the relationship between mental representation in cognitive terms and internal representation in linguistic terms; (2) what is being represented; (3) the numerous sources of input that contribute to representation; and (4) how representation is defined in terms of dynamic systems theory. This part of the chapter serves as a bridge between a description of divergent theoretical frameworks and subsequent chapters that deal specifically with templatic theory, dynamic systems theory, and schema theory. This dissertation connects these three theories in the construction of a novel approach to early phonological development, with the aim of contributing a more nuanced understanding of the processes involved.

1.2 Theoretical perspectives on phonological development

1.2.1 Nativist models

The long-standing problem of language acquisition concerning how a child acquires language with remarkable rapidity using relatively limited input has invited a range of theoretical approaches. Nativist views span structuralist to generative to constraint-based theories, each built from the assumption of innate language-specific structures or capacities that enable a child to acquire a highly complex linguistic system. Employed as support for this approach, the poverty of the stimulus argument holds that the child receives far too little input to infer a complex system of linguistic structures and rules, and so a certain degree of linguistic capacity must be innate (Chomsky, 1980). This linguistic capacity in the modern tradition is Universal Grammar, a biologically endowed set of formal linguistic principles that allow a child to acquire the grammar of the language(s) to which he or she is exposed. Universal Grammar purports to offer a solution for how children uncover the grammar of the ambient language not available in the input, and a language acquisition device is proposed as a module in the mind that imparts to a child an innate predisposition toward learning language (Chomsky, 1965).

Differences between variants of nativist theories lie in the means by which the principles of Universal Grammar enable a child's prelinguistic state to develop into an adult-like system. Clahsen (1992: 53) describes three main strands of thought concerning language learnability, which boil down to choice, maturation, and continuity, each of which takes Universal Grammar as a starting point. "Choice" pertains to the idealized scenario of generative grammar wherein two linguistic states are proposed: a prelinguistic state with grammatical parameters yet to be set, and a final state in which parameters for a specific language have been set. While this approach is not capable of explaining the way a developmental course unfolds, the Maturation Hypothesis and the Continuity Hypothesis, which offer opposing perspectives on this issue, aim to do so (Clahsen, 1992). Clahsen's (1992) points frame an interpretation of syntactic data, but the theoretical perspective can be applied to phonology.

The Maturation Hypothesis states that the emergence of the principles of grammar in a child is not dependent on input from the environment. That is, they are not learned. Rather the principles of Universal Grammar emerge over time, guided by a predetermined course (Borer & Wexler, 1987; Felix, 1984). Jakobson's (1941/1968) structuralist approach to phonological acquisition takes a position on two points that continue to be debated in the acquisition literature: one is a deterministic view of the course of development, and the other is a universalist perspective on the sounds that emerge in early grammars. In Jakobson's conception, a child's phonological system unfolds according to an innately defined developmental path, and the phonological units in the system develop regardless of the components of the ambient language. With this, acquisition is seen not to be accumulative but rather to involve restructuring across stages: At the outset, child and adult grammars are fundamentally different. The child borrows from the target adult grammar, replacing and eliminating his or her original grammar, as a self-contained phonological system unfolds in predetermined sequence, guided by a universal set of contrasts (Jakobson, 1941/1968: 14). Data from Velten's (1943) diary study of the child Joan are analyzed through this lens (described in Chapter 2). Goad and Ingram (1987) support Jakobson's deterministic claims about the acquisition of a phonological system but reject his universalist claims, aiming to explain individual variation by arguing that the order of acquisition depends on the language being acquired.

Rice and Avery (1995), nevertheless, argue that individual variability can be appropriately addressed within a deterministic framework rooted in nativist theory. They focus their theoretical approach on segmental structure, which they claim at the outset bears underspecified and “impoverished” representation that becomes more elaborate. For example, they argue that early segmental representation is not specified for Place (i.e., place of articulation), but rather more broadly only for C (consonant) and V (vowel). As a result, they argue, various distinct consonants may be produced for a given target consonant. Whole-word approaches to early phonological development offer a more comprehensive analysis making use of the child’s entire repertoire of sound patterns (Ferguson & Farwell, 1975; Macken, 1979; Waterson, 1971). Rice and Avery (1995) acknowledge individual variability, and integrate within their theory the idea that children have their own grammars which by restructuring come to maturity to match adult grammars, but cast it as separate from phonological significance. An example is found in their explanation for a child’s individualized preference for a particular sound as merely a choice the child made to fill a bare slot for Place within the structure of a segment. Research on the relationship between babbling and first words illustrates that preferred sounds are not so random (Cruttenden, 1970; Elbers & Ton, 1985; Jaeger, 1997; Macken, 1979; McCune & Vihman, 1987), as does research on the use of whole-word patterns in early development (Macken, 1979; Priestly, 1977/2013; Vihman & Croft, 2007). In deterministic models of acquisition, the trajectory of a child’s path toward an adult-like system is seen to transition from stage to stage, at which points the grammar is assumed to expand to cover new structures, reconfiguring so that old, irrelevant structures are no longer used (Felix, 1992). Regardless of whether individual variability is considered to be part of the picture, this model has discontinuities built into it as the child graduates from stage to stage.

In contrast with this view, the Continuity Hypothesis (Pinker, 1984) assumes continuity across stages of phonological development and, with this, all innately specified linguistic principles are available from birth at all stages of development. In this view, the principles of Universal Grammar are not subject to change over time or replacement in the transition from one developmental stage to another. Rather, input from the environment is required to trigger the availability of innate principles that were not previously available to the child (Clahsen, 1992). Fee (1995: 47) argues that the same Universal Grammar constraints that operate in adults also operate in children and represent the unmarked aspects of phonological systems (i.e., the less distinctively identified aspects). This includes both the linguistic units composing a phonological system and the rules that act upon them. Fee (1995) gives as an example a rule for building a core CV syllable provided by Universal Grammar. Fee (1992) and Demuth and Fee (1995) argue for an innate principle guiding the construction of minimal words in early development (i.e., a word containing at least two syllables or two moras, rendering it prosodically well-formed), drawing the focus from segments (as in Chomsky & Halle, 1968) to prosodic units in acquisition paths. Indeed Fee (1995) argues that features, segments, syllables, and words all serve as organizational units early on, disregarding the first 50 words that are typically learned as whole words. The first words, which do tend to be learned as whole-word units, are precisely those that Vihman and Velleman (2000) cite as the organizational units in the construction of a first phonological system. This dissertation argues that first-word data are critically important in shaping a child's path of acquisition.

The generative approach inscribes rule-based scenarios aiming to draw a path between a child's linguistic competence—what he or she is purported to know—and linguistic performance—how linguistic knowledge is realized in use. Smith's (1973) reputable study of his son Amahl employs the generative framework developed in Chomsky and Halle (1968), presenting a rich longitudinal study with the intention of demonstrating the relationship between child and adult pronunciation. In this framework, the child comes endowed with innate linguistic capacity comprised of universal properties, which exposure to the set of abstract rules in the ambient language (or languages) shapes into an adult-like grammar. With this, the child's output forms are realized by way of rules acting upon underlying representations that match forms in the adult input.

Smith's (1973) model assumes that the child is working with the correct lexical representation in production, and realization rules act on this representation to result in the child form. Braine (1976) criticizes this assumption, citing the occurrence of inter-word segmental variation that is not a result of phonetic environment in child data. For example, this occurs when a child produces [gʌk] for *duck* and [dædi] for daddy, where the initial /d/ is produced as [g] in one word and [d] in another word, with no phonetic explanation. Braine (1976) argues that this phenomenon could not occur if the child had the "correct" representation matching the adult target, a point that supports early whole-word representation in child phonological systems. Macken (1980) also offers a reanalysis of Smith's (1973) data, demonstrating the presence of "non-adult" lexical representation, which she argues results from the child's misperception of the adult form. Upon these conclusions, she builds a model founded on two types of rules—perceptual encoding rules and output rules (i.e., articulatory rules), which boil down to a single-lexicon model of phonological representation, reconceptualizing Smith's (1973) formulation.

Another point on which Smith's (1973) analysis falls short is his claim of across-the-board change when new sounds were added to Amahl's phonological system. Smith (1973: 140) observes, "Usually any change was spread over a period of several days or, rarely, weeks, with free variation between the old and new forms occurring first in a few words, then in a majority, and then again in just a few stragglers." Although Smith acknowledges that the "across-the-board" nature of the change he describes is not complete, the fact that change is spread over a period of time and leaves stragglers is important and should be considered integral to the acquisition process rather than simply exceptional. This is precisely the kind of phenomenon that dynamic systems theory can account for and, in fact, points to as being involved in and driving change in a system (Gershkoff-Stowe & Thelen, 2004; Thelen & Smith, 1994). Dynamic systems theory is discussed in detail in Chapter 4.

In response to problems left unsolved by generative approaches assigning linear rule-based processes relating linguistic competence and performance, constraint-based approaches, like Optimality Theory (OT; Prince & Smolensky, 1993-2008), have been proposed. These approaches rely on a set of constraints common to both the child and the adult, but which differ in ranking (Kager, Pater, & Zonneveld, 2004). OT turns the focus from linear-ordered rules to representations and the interaction between hierarchically ranked faithfulness and markedness constraints on output forms. In contrast with rule-based frameworks, the learnability of an OT grammar requires addressing the means by which constraints are re-ranked as the child proceeds from an immature to a mature grammar, variability within a grammar, and what becomes of constraints involved with phonological processes that typically only occur in child language (Kager, Pater, & Zonneveld, 2004), like velar fronting, consonant harmony, and long-distance metathesis (Rose & Inkelas, 2011).

Becker and Tessier (2011) present an OT-based approach aiming to account for apparent variability within and across stages in a child's grammar. While the authors assume a common set of constraints between child and adult, they posit that children can deduce their own constraints along the way, which may result in some child-specific phonological patterns. Highlighting the problem of how, then, to account for what happens to child-specific constraints that are not seen in adult grammars, the A(rticulatory)-Map model (Byun et al., 2016: 69) ascribes these patterns to "the influence of a universal constraint favoring forms with a history of reliable articulatory execution". In this way, child errors in production aimed at adult target pronunciation become "phonologized" due to the temporary functional pressures of an immature articulatory ability and then dissipate as the child matures. This is in the context of two tensions which the authors propose influence the formation of an adult grammar out of the child grammar: (1) the pressure to produce a word that matches the adult pronunciation and (2) the pressure to reliably execute a pronunciation that the child is capable of producing at the time, whether the pronunciation is accurate or not.

The A-Map model handles some variation and the fate of child-specific constraints quite well. It claims also to be able to handle templates, but it is not clear how this might be so. As will be discussed in Chapter 3, the nature and behavior of templates is complex, and the influence of patterns affecting whole words on other sounds and patterns in the child's repertoire may be difficult to account for in a system of universal constraints. One reason is because individual differences are seen early in development (Ferguson & Farwell, 1975; Khattab & Al-Tamimi, 2013; Vihman, Ferguson, & Elbert, 1986), when templates are observed. These differences can be explained by looking to the individual child's developing phonological repertoire, beginning with the emergence of prelinguistic vocal patterns (see Chapter 3).

1.2.2 Emergentist models

One critical difference between generative and emergentist approaches is that between the idea of categories of sound and symbol tokens (Port & Leary, 2005). Where generative theory says representation is comprised of cognitive symbol tokens, emergentist approaches say that categories of sound can be acquired without the formal power of symbol tokens. The difference lies in the nature of categories and how they are represented. In dynamic systems theory—an emergentist approach to development employed in the present research—the capacity for word production emerges as a result of a complex of actions (Browman & Goldstein, 1995), and representation is conceived of as the continuously changing interactivity of processes. Another important point of contrast is that where nativist theories of language development are adult-centered formal approaches, emergentist theories focus on the child and language use. This difference can be seen in generative analyses of phonological acquisition data that hinge on rules exhibiting how child forms are derived from adult forms, in contrast with emergentist analyses that look to the patterns in an individual child's repertoire developing in interaction with each other.

In this way, emergentist theories of acquisition describe language as being usage-based, so abstract linguistic structures develop by way of language in use (Behrens, 2009; Bybee, 2001). This feat is largely dependent on the cognitive abilities of pattern-finding and generalization. Some innate capacity must be involved in any theory of language. Language is, after all, subject to the cognitive processes bound by neural mechanisms inherent to human beings. Emergentist theories assume the sufficiency of interacting non-modular general cognitive capacities powerful enough to isolate and extract linguistic patterns from the input a child receives. In contrast with nativist theories assuming the innateness of linguistic structures housed in a language module, emergentist theories typically assume that patterns discerned from the interaction of cognitive and social pressures on language use give way to formal linguistic structure. In analogy, MacWhinney (1998: 201) offers that this happens "[m]uch as the shape of the coastline arises from the pressures exerted by ocean currents, underlying geology, weather patterns, and human construction". That is, diverse and domain-general processes—involving the cognitive, the social, the biological—interact, creating circumstances out of which linguistic structure emerges in a way particular to that set of circumstances and the language learner. While an argument can be made that language is emergent yet modular, evidence that modularity seen in adulthood results from specialization during development (Ellis, 1998; Elman et al., 1998) dissuades easy acceptance of this view.

The issue of modularity has prompted much debate in psychology and philosophy (Barret & Kurzban, 2006; Robbins, 2013) and is beyond the scope of this dissertation. The position taken here assumes domain-generality in the course of development as packaged in a dynamic systems theory approach (Thelen & Smith, 1994).

The connectionist model of cognition has been used to explain how the monumental task of language emergence takes place. Connectionism responds to the weaknesses of computational theories centered on static symbol systems, and its aims are to describe cognitive abilities by modeling artificial neural networks and the variable strength of connections between units in the network (Garson, 2015). Representation, in this way, rather than being composed of static symbols subject to rules, is distributed across neural networks. Gerlach (2010) uses an OT variant employing a connectionist framework, based on Bernhardt and Stemberger (1998), to address the acquisition of consonant sequences. The framework importantly distinguishes the universality grounded in the cognitive and articulatory limitations of the child from the property of innateness. Gerlach claims, "Universal phonological tendencies are reflected in constraints that emerge in each speaker due to the principles of cognitive processing and the physiology of the vocal tract" (2010: 31), and Stemberger and Bernhardt (1999: 444) assert that "children possess no innate phonological skills and must learn to do everything". As a consequence, children must learn to execute both the planning and articulation of sound sequences. A connectionist model assists an OT approach by allowing for more freely variable constraints dependent on the child's learning experience.

Menn et al. (2013) present a linked-attractor model inscribed within a connectionist framework, developed to improve on an older two-lexicon model that runs on two kinds of rules: (1) selection rules, which contain aspects of the adult words that the child stores, and (2) production rules, which are motor execution rules that fill the gaps in the child's output forms (Menn & Matthei, 1992). Selection rules ostensibly disappear when no longer relevant, and production rules become increasingly adequate with increasing knowledge. Menn and Matthei (1992) argue that a connectionist model can support fuzzy boundaries between categories, child forms that interact, frequency effects, and the linked fashion in which input and output forms are stored. While the model was designed to account for noise in child phonological systems, it is challenged by the phenomenon of variation in the pronunciation of a given word at a given time. In the data at the center of the current work, for example, the child produced six variants for the target *giraffe* within a period of five minutes. This is a phenomenon for which the two-lexicon model struggles to account. The templatic approach, particularly as it is supported by dynamic systems theory, expects variation of this kind and is capable of explaining it (see Chapters 3 and 4).

As a psycholinguistic model uniting Menn and Matthei's (1992) two-lexicon model and Vihman and Croft's (2007) templatic approach to representation in phonological development, the linked-attractor model aims to capture the real-time operations in which a child links the way a target is heard to how he or she will pronounce it. Claiming that Vihman and Croft's (2007) model needs to be fleshed out in order to explain how and why the gap between child forms and their target adult forms gradually closes, Menn et al. (2013) propose the linked-attractor model, exploiting variable degrees of connection strength between phonological units in a dense network. The model holds promise to satisfactorily handle the noise that nativist theories have struggled to address comprehensively, and it may serve well as an additional supporting framework for the theory constructed in this dissertation. Future research placing whole-word templatic categories in a connectionist model will be able to determine the compatibility of the models, but this is beyond the scope of this dissertation. The present research importantly provides clarity on the nature of representation in early acquisition, depicting a means of tracing changes in mental states as the gap closes between child forms and their adult target forms.

Vihman et al. (1994: 284-285) observe that connectionist models can account for much of the early period of phonological development, but suggest that a theory like dynamic systems theory is more appropriate because it can capture shifts in which "something changes" in a system, noting that the "advent of phonological systematicity is rooted in cognitive advances" (284). While dynamic systems theory interprets a system as part of an entire organism's set of interacting systems, connectionism falls short by not doing so (Thelen & Smith, 1994). Connectionist and dynamic systems approaches to development each share a reliance on emergentist principles and grow out of similar mathematical foundations distinct from innate symbol systems, but the two ultimately differ (Smith & Samuelson, 2003). While a dynamic system can run on connectionist principles, a connectionist system is not necessarily a dynamic system (Smith & Samuelson, 2003). Connectionism is built on theoretical ideals that vary in the strength of connections between units, but dynamic systems theory depends on the multiple causality of observable events in interacting systems.

To reiterate a fundamental point in this chapter, the way representation is defined offers a critical distinction between emergentist and nativist theories. Nativist theories assume a system comprised of a set of symbols on which computational rules act. Both connectionist and dynamic systems approaches eliminate the static quality from representation, replacing it with more kinetic processing. In connectionist theories, representation is distributed across the connection weights between units in a network. Dynamic systems theory dispenses with the very notion of static representation, conceiving of knowledge distributed across many kinds of processes participating in a given behavior. Again, dynamic systems theory interprets a system in context with an organism's entire set of interacting systems. With the view that gaining a thorough understanding of the acquisition of language and of language use requires an understanding of processes beyond only language structure, the current work approaches phonological development from a dynamic systems theory perspective (Thelen & Smith, 1994), supporting a templatic approach to representation, in union with schema theory. As this chapter intends only to give an overview of nativist and emergentist theories, a detailed discussion of the three emergentist frameworks employed in the present research appears in the following chapters.

Elman (1998: 21-22) points out that neither inevitability nor universality justify labeling a behavior or capacity as innate. A child exposed to language will acquire language and children share certain inclinations toward the sequence of elements acquired, but it does not follow that linguistic structures are necessarily innate. According to Mohanan (1992), nativist arguments incorrectly presuppose that knowledge of linguistic structures is identical across speakers. Observations of templatic behavior offer evidence that contradicts nativist assumptions about linguistic categories, and dynamic systems theory provides a means of explaining how phonological systems might emerge in different sequences in different children to contain similar contents across children acquiring the same language without having modality-specific innate structures as starting points.

While the current work argues for the superiority of dynamic systems theory to sufficiently account for the processes in early phonological development, it is possible that different kinds of theories need to be used to understand different kinds of phenomena at different stages of development. Menn and Matthei (1992) point out that neither rules nor constraints can deal with the property of time in linguistic processes, which supports an emergentist framework. Additionally, Menn et al. (2013: 495) suggest that all of generative, OT, and templatic approaches may be needed to fully grasp phonological development at different resolutions. The developmental period during which templates are typically observed to emerge, nevertheless, seems to be best encapsulated by the tenets of dynamic systems theory.

1.3 Representation

Vihman et al. (1994: 264) describe mental representation as a "contentful mental state distinguished from perception by its capacity to reference absent and past realities". In terms of phonology, representation generally means mental storage and is established at the point when a child makes use of abstract linguistic knowledge to produce meaningful utterances, having transitioned from prelinguistic sounds grounded in phonetic experience. This transition does not happen overnight. Vihman et al. (1994) describe two theoretical positions on mental representation: one in which representation is present from birth (Leslie, 1987), and one in which representation develops during the first two years of life (McCune-Nicolich, 1981). The templatic approach assumes the latter, focusing on the period of phonological development when a child's representational capacity emerges in the first organization of a phonological system. The current work introduces schema theory to the templatic approach in order to depict something akin to varying degrees of abstraction involved with developing representation during this period. Again, adapting the templatic and schematic frameworks to dynamic systems theory, what is referred to as representation in this work is conceived of as processes in use at differing rates of productivity.

The core difference between different models is in the nature of representation during the course of phonological acquisition. In addition to Macken's (1980) model, Ingram (1974) also describes a single-lexicon model in which a single underlying form differs from both the adult and child pronunciations due to the inaccurate perception of adult forms by the child. Underlying forms are theorized to contain some fully specified segments and other abstract placeholders for segments the child cannot pronounce, which are guided by the child's abstract phonotactic and segmental substitution rules. Critics of a single-lexicon account claim that children can usually accurately perceive adult words and point to the inability of the model to handle that (Dodd, 1975; Jaeger, 1997). A two-lexicon model was developed in response, as in Menn and Matthei (1992) as described above, which exploits imperfect representations of perceived target adult forms separate from low-level motor execution representations involved with online word production.

Criticism of two-lexicon models for being inefficient and lacking parsimony prompted an enriched single-lexicon model. In contrast to earlier single-lexicon models, Iverson and Wheeler's (1987) model assumes no derivational relationship between perception and production forms. Rather than separate perception and production lexicons, a single lexical representation contains both a perception and a production representation. The former is based on the adult input, and the latter is constrained by the possible word-shapes in the child's current phonological system. Jaeger (1997) argues for the adequacy of an enriched single-lexicon model to account for templatic patterns in data from a single child, "Alice". She suggests that to explain the consistency of word-based patterns, Alice must have had a representation of "a general word template…which she used in acquiring new words" (1997: 24). If children perceive adult words accurately, as has been claimed (Dodd, 1975), then accounting for the phenomenon of word templates using a basic single-lexicon model, according to Jaeger (1997), is problematic.

These approaches to representation and the nature of the lexicon differ in how they conceptualize the way a child gets from the adult forms he or she hears to the form that he or she produces, which often is much different. Jaeger's (1997) observations highlight the presence of templatic patterns that need to be incorporated into a description of representation in a developing phonological system. The nativist models described above depict static representational units, which do not suitably reflect rapidly changing patterns that affect whole words. A child's phonological system is grounded in phonetic beginnings (Munson et al., 2012; Vihman et al., 1994), and Lindblom (1999: 13) points out that "[f]or the child, phonology is not abstract. It represents an emergent patterning of phonetic substance". Building on these points, a theory of phonological acquisition must explain the processes involved as an incipient phonological system develops from a low-level degree of abstraction to a more highly abstract one. Focusing on the early period of development in which templatic behavior is often observed, the present research introduces schema theory in order to depict and explain these processes.

Dynamic systems theory ties together the templatic framework and schema theory, emphasizing the continuously changing processual nature of linguistic information, subject to influences beyond linguistic structure. Munson et al. (2012) describe phonological representation to be composed of auditory characteristics of sounds they produce and that they hear others produce, visual characteristics of seeing others produce language, and also tactile, kinaesthetic, and somatosensory characteristics of sounds produced. With this sort of scope in view, Menn et al. (2013: 486) refer to a "multidimensional hyperspace" that is required to fully model word representation and point out that theory that is purely linguistic is not able to handle "accidental history" like family names, television to which a child might be exposed, and other factors contributing to linguistic knowledge. A phonological system in the process of development is subject to continuous change, affected by a variety of linguistic experiences and also cognitive and biological advances (Munson et al., 2012). This is the view that is adopted and explored in the current work, and it precludes Jaeger's (1997) argument that templates render a basic single-lexicon model problematic. In this view, there is neither one nor two lexicons, but rather a system of continuous processes contributing to multidimensional states. An appropriate term to be used in place of "representation" might be "time-dependent states"; however, for ease of reference within the literature, the term "representation", reconceptualized as described within this chapter, is used in this work. The next three chapters discuss, in order, the templatic framework, dynamic systems theory, and schema theory, and the suitability of each separately and together to enhance our understanding of early phonological development processes.

1.4 Summary and overview of the chapters

This introductory chapter has aimed to contextualize an argument for an emergent theory of language by presenting a range of theoretical perspectives on language acquisition. Chapter 2 provides a history and reflection on the tradition of diary studies as employed in phonological acquisition research. This is important because there is warranted skepticism about the validity of diary studies. Chapter 2 aims to make clear, in acknowledgment of this, why diary studies are not only useful but also necessary, particularly when targeting data at the onset of word production.

Because this research develops a theoretical framework by uniting three theories, careful description of each of these theories is crucial. Chapters 3, 4, and 5 lay out the templatic approach to representation in phonological development, dynamic systems theory and its utility in an approach to phonological acquisition, and schema theory as part of the cognitive linguistics program. The chapters of analysis—Chapter 7 (templatic analysis) and Chapter 8 (schematic analysis)—present early acquisition data from four American English-acquiring children, provide measures of templatic behavior, and illustrate important points concerning the utility and value of the present framework.

At the heart of this research is a reconceptualization of developing representation as time-dependent states subject to a multitude of interacting processes. The templatic approach describes early representational content identified in the phonetic forms that children produce. Schema theory plays an important role because it completes the picture of how phonological templates are drawn into any given utterance, including variant utterances for the same target word, as is often seen in early child data. Dynamic systems theory is highly informative for understanding development processes (Thelen & Smith, 1994), and is called upon as an appropriate theory by which to interpret templatic behavior (Vihman et al., 2009). This research delves into the conceptualization of templates within dynamic systems theory by identifying how central concepts within dynamic systems can be used to understand templatic function. Accordingly, again, the conception of representation as interactive processes active in continuous time is adopted. As such, schema theory depicts snapshots of categorizing structures along various points in these processes, facilitating a close look at incipient phonological patterns interacting in an increasingly complex system.

Chapter 2: The tradition of diary studies

2.1 Introduction

Data collection across the stages of acquisition is essential for constructing and fine-tuning theoretical models aiming to describe the processes involved with phonological development. Child phonological data present a wide range of phenomena, including exceptional forms, all of which any given theory must be capable of explaining. Diary studies have long been an important source of phonological acquisition data, particularly when little was known about child language. This chapter begins by defining the nature of a diary study, then briefly outlines the history of diary studies, accompanied by description of a few seminal studies that have contributed to our knowledge of phonological development and, in some cases, more specifically to our understanding of whole-word patterns in the early stages of development. This chapter also discusses the advantages and disadvantages of the diary study.

2.2 What is a diary study?

A diary study assumes a longitudinal framework within which to examine a phenomenon in one or two subjects. In a diary study investigating phonological acquisition, data collection is centered on the sounds a child produces, often either at the onset of word production or after word production is established but before the child has acquired an adult-like phonological system. If the goal of the study is to examine child phonological processes, the study will typically involve children at the onset of word production or later up through approximately age 4;0, investigating phenomena common in child language, like velar fronting, metathesis, consonant harmony, consonant cluster reduction, or the production of a certain sound (e.g., Inkelas & Rose, 2003; Jongstra, 2003; Vihman, 1978). If the goal is to examine the processes of phonological acquisition, a study of production data at the onset of word production is necessary (e.g., Macken, 1979; Smith, 2010; Vihman & Vihman, 2011), and examination of prelinguistic babbling is additionally informative (e.g., Elbers & Ton, 1984; Vihman, Ferguson, & Elbert, 1986). Diary studies investigating phonological acquisition typically focus on production data documented by way of broad transcription and sometimes also involve tape- or video-recordings for the purpose of transcription checks and supplementary acoustic analysis.

Diary study data are collected in a small variety of ways. In probably the best case, a researcher who is typically a linguist and also a parent of the child collects data, bringing together field expertise and singularly intimate knowledge of the child being studied, enhanced by the nearly constant opportunity to collect data (e.g., Waterson, 1971). In other cases, someone who has ready access to a child in the early stages of language acquisition is the researcher (e.g., Smith, 2010). In other cases, researchers provide instructions to parents for collecting data and also visit the child's home themselves (e.g., Compton & Streeter, 1977), or data collection is entirely the responsibility of researchers who either visit the child's home or have the child visit the researcher's laboratory at regular intervals for defined periods of time in a given duration (e.g., Ferguson & Farwell, 1975/2013). During regular sessions, the child's production attempts are transcribed and notes are taken, often supplemented with recordings.

Phonological diary study data are collected by means more exploratory than systematic. During a visit or session (or while the parent-researcher is present), the researcher may document spontaneous speech, transcribing or recording whatever utterances the child produces upon his or her volition. Another method is elicitation, involving attempts to guide or prompt word production by showing a child picture books or toys or pointing to things around the room. Documenting spontaneous speech while also eliciting speech can be advantageous for the purpose of acquiring a greater quantity of data. Elicitation of speech is additionally useful if a researcher is curious about whether or not a child is able to produce a given sound and how the child might do so (e.g, Smith, 1973).

Distinction is usually made between imitated and non-imitated speech, although it can be problematic to enforce such a distinction. Typically the purpose of attending to non-imitated rather than imitated speech is to obtain utterances processed by a child's developing phonological ability in contrast with the ability to imitate. Ferguson and Farwell (1975/2013: 96) did not exclude imitated forms in their study of seven English-acquiring children, arguing that it would result in a paucity of data of reduced utility. They point out that in addition to data being limited in the first place, many utterances produced by a child at age 1;0 are imitated. Furthermore, they note that it can be difficult to distinguish between the two types of utterances; namely, it must be decided how much time is allowed to pass after an adult utterance for a child utterance to still be considered to be imitated. Priestly (1977/2013) deliberately elicited forms, inducing imitation, with the aim of obtaining a more complete data list. Menn et al. (2013) highlight the importance of incorporating frequency effects in a model of phonological acquisition, arguing that each instance of a form heard, articulated, and thought but not spoken by the child reinforces that form in the child's developing grammar. When the diary study at the center of the present research was conducted, imitated utterances were excluded for the purpose of obtaining knowledge about the child's abstract system. As a result, utterances representing each distinct pronunciation produced by the child (i.e., Djuna) are available, but frequency data reflecting imitated and repeated utterances are not. Upon further investigation, however, it seems more advantageous, in view of the usage-based framework later incorporated into this research, to include imitated utterances. Doing so at this point is not possible; however, the research is pursued using the data available. While the inclusion of imitated utterances would have enhanced the results, their exclusion likely does not skew the ultimate conclusions.

Diary studies serve as a valuable means of data collection for examining the chronology of sounds a child is capable of producing (Velten, 1943) and individualized developmental paths (Ferguson & Farwell, 1975/2013; Priestly 1977/2013). Large-sample longitudinal studies and lab studies are designed to collect targeted data in a systematic way, which may be more clearly generalizable to other children. Diary studies that focus on production in the transition between babbling and first words and at the onset of word production, however, necessarily provide a view of the full range of sounds and sound patterns as a phonological system is being constructed (Elbers & Ton, 1984; Vihman, Ferguson, & Elbert, 1986). The resulting data set can be unruly. While some phenomena can be understood by focusing on child forms exhibiting the targeted pattern (e.g., segmental substitution), in other cases a more complete view of a child's phonological system is necessary (e.g., unsystematic metathesis). Data that present such a whole view of a child's developing system, thus, are of value in phonological acquisition research.

2.3 History of the diary study

Studies of child language development appear in the literature since at least the late nineteenth century (see Fikkert, 2000). Many early studies were conducted by psychologists and developmentalists who did not have substantial knowledge of linguistics (see Jakobson, 1941/1968). While the earliest diary studies of phonological acquisition were approached with little systematicity, they continue to provide insight into the kinds of information that can be obtained, revealing methodological or analytical points on which subsequent studies can improve. Because not much was known about child language when the earliest studies were conducted, they were primarily descriptive (e.g., Leopold, 1939-49; Velten, 1943) and were carried out by way of parental diaries. These studies laid important groundwork, collecting information about how structural and behavioral patterns evolved as children begin to acquire language and in what order they acquire the elements of linguistic knowledge. The following paragraphs highlight important ideas and conclusions by way of a few seminal studies.

2.3.1 An early diary study: Velten (1943)

Velten (1943) conducted a diary study of his English-acquiring daughter Joan's phonological and lexical development, following her development from age 0;11 to 3;0. At the time, most studies of acquisition in English-acquiring children dealt with morphology and syntax. Few methodological details are provided, although Velten

(1943) describes Joan's linguistic and developmental environment. English was the language primarily spoken at home; however, French and Norwegian were also spoken to a lesser degree. While Joan is reported to have developed a substantial passive vocabulary in these languages, she began producing English words at the onset of word production. Data are presented according to the child's age by the month during which an utterance was produced.

Between Joan's third and eighth month of age, she was "particularly addicted" to the velar [g] and to voiceless palatal spirants (Velten, 1943: 281). As is illustrated in the templatic literature (Macken, 1979; Menn, 1971; Priestly, 1977/2013; Waterson, 1971; Vihman & Vihman, 2011), children commonly show preference for a particular sound or sound pattern defined by whole-word shapes, both prelinguistically and in early word production. Notably, the sounds for which Joan showed early preference in her words were prevalent during the babbling stage.

Velten (1943) does not make clear how the emergence of phonemes was determined, but he observed that when phonemes begin to appear in Joan's phonological repertoire, many other sounds she had been producing disappeared from her speech. When phonemes first appear, Velten (1943) notes,

> the use of distinctive sounds is at first severely restricted because a child does not acquire a phoneme system by random selection or by taking it over ready-made from the language of the adults, but by proceeding, step by step, from the greatest possible phonemic distinction to smaller and smaller differentiations. *The process is identical for children of all linguistic communities* [emphasis added]. (282)

This observation describes a process examined in detail in the present study. That is, a child begins with a limited and broadly defined set of sounds in his or her inventory and gradually refines knowledge that becomes part of the abstract system. Velten (1943: 292) refers to "the transformation of phonetic variants into phonemes" and provides details about the chronology of the appearance of phonemes in the child's production. For example, the child began with a vowel "usually of the widest opening" and a consonant "produced by complete closure of the oral and nasal cavities" (1943: 282). Next came a continuant, a stop, a second continuant, and then a vowel. These sounds, vaguely defined, composed the inventory of sounds in Joan's early word production, and more nuanced contrast developed as the child acquired more knowledge of the ambient language. Joan's first words are listed in (1):

(1)	[ɑp]	"up"	age 0;11
	[bɑ]	"bottle, bang"	age 0;11
	[bɑs]	"(omni)bus"	age 1;0
	[bɑzɑ]	"put on"	age 1;0
	[zɑ]	"that"	age 1;0

(Data from Velten, 1943: 282)

The words in (1) use only the early sounds that Velten observed following the emergence of the first consonant and first vowel: two continuants [s, z], a stop [b, p] (two stops here, although few children at this age have mastered the voicing feature), and a vowel [ɑ]. Velten additionally describes, in the period before phonemic distinction becomes more nuanced, sounds that are allophonic in the child's phonological and lexical development, which are not allophonic in the ambient language (e.g., [hw] and [f]). Similarly, Ferguson and Farwell (1975) trace the acquisition of initial consonants, reporting emergent phone classes, which in the early stages do not correspond to what we find in the ambient language. Velten (1943: 284) describes the early production of words as having "the character of loan-words", reporting slow initial phonological development in contrast with rapid increases in vocabulary. This resulted in a large number of homonyms. Homonyms have repeatedly been reported in early child language (Ingram, 1975; Lleó, 1990; Priestly, 1980; Tervoort, 1969; Waterson, 1971).

Only after Joan had been producing words for seven months (at age 1;10) did she begin to produce two distinct vowels (i.e., [ɑ] and [u]). Velten presents in detail points at which a given sound or syllable pattern enters the child's repertoire and appears to contribute to changes in the child's production of particular words. For example, Joan initially produced "bottle" using a CV syllable pattern, [bɑ], then began to produce [bɑz] after acquiring a large number (it is not given in the text how many) of new words using a CVC pattern. During the same period of time, other child CV forms that might have taken on a CVC pattern to match the adult targets (e.g., [bɑ] "bang, shut" and [zɑ] "that") retained their initial pronunciation for as long as 18 months. Velten cites frequency as one property of change-resistant productions (1943: 284). The phenomenon of entrenchment of certain forms due to early emergence and frequency of usage has been reported elsewhere (Macken, 1979; Oliveira-Guimarães, 2013; Vihman & Croft, 2007).

Knowing how many new words used the CVC pattern and the frequency of these utterances when some of Joan's older pronunciations adapted to use this pattern could tell us more about how the developing phonological system on the whole responds to changes in its individual components and at what points we might pinpoint thresholds of a given pattern being newly produced, which precede change. Velten (1943) concludes that the child's development may serve as a tightly compressed model of diachronic change, in that the processes of linguistic change seen across time in a speech community are seen on a smaller time-scale at the level of the individual. It is not clear how this is so. Whether or not this conclusion can be drawn may depend on how close in focus the system is viewed, but a gamut of subsequent research shows that children—even those acquiring the same language—follow at least somewhat idiosyncratic paths (Ferguson & Farwell, 1975; Vihman, 1996; Vihman, Ferguson, & Elbert, 1986; Vihman & Greenlee, 1987). Velten provides analysis of his daughter's data up through about age 3;0, incorporating commentary on the acquisition of morphemes into phonological analysis, with the aim of tracing the development of phonetic variants into phonemes. He follows the child's acquisition of particular segments, cluster production, and voicing distinction, focusing some of the analysis on positional information. For example, Joan resolved neutralization of /p—b/, /t—d/, and /s—z/ in initial position at age 2;1, and stopped neutralizing these "oppositions" in the medial position at age 2;3 (Velten, 1943: 290). Interestingly, Goad (2011) analyzed data from Amahl (Smith, 1973) and showed that voicing distinction appears in the medial position before the initial position for articulatory and perceptual reasons. In this way, while a diary study like that reported in Velten (1943)—or that reported in Smith (1973), discussed below—presents data for only one child, the data reap valuable, detailed information about one child's acquisition processes that can be usefully compared with that of others.

Because the study is described as "based on a record" of Joan's speech development and because the researcher is Joan's father (Velten, 1943: 281), present commentary on the study's methodology cannot be extensive. This is unfortunate since greater detail could inform subsequent analysis; nevertheless, Velten's intimate knowledge of his daughter's phonological development is clear. Record of the timeline of word production and the points of introduction of new sounds and syllabic patterns allows a chronology to be followed. Diary studies, in general, because they provide longitudinal data focused on the development of one child, offer continuous temporal knowledge. This quality is especially important to note in context with dynamic systems theory, built in part on the idea continuous time (Smith & Thelen, 2003). This topic is discussed in detail in Chapter 4. What is gained from Velten's study is access to the detailed development of the sound inventory of one predominantly English-acquiring child transitioning from babbling into word production, and insights from the study inform valuable comparisons with other acquisition studies of English phonology.

2.3.2 The relationship between child and adult forms: Smith (1973)

Working within a generative phonology framework (Chomsky & Halle, 1968), Smith (1973) analyzed phonological acquisition data collected from his son Amahl. The purpose was to characterize the nature of regularities as the child progressed from "a more idiosyncratic and simple system to one which was more complex and more closely isomorphic with the system of the adult language" (1973: 1). Data were collected from Amahl at age 2;2 through 4;0, and were collected "systematically" by phonetic transcription on index cards (1973: 9-11). Most utterances were produced spontaneously, but occasionally Smith aimed to elicit a particular word and, on rarer occasion, aimed for the child's imitation of a word. Some recordings were made using a tape-recorder for the purpose of the child hearing himself, but Smith notes that these recordings were not as useful as expected, at least not for the purpose of confidently connecting a given utterance to its referent. He, furthermore, refers to the "impracticability" (Smith, 1973: 10) of recording child speech in the earliest stages.

Smith's (1973) study is known for its thorough documentation and analysis. Data were collected either weekly or daily, depending on "the instability of [Amahl's] system]" and available time (Smith, 1973: 10). Analysis focused on the relationship between child and adult forms. To formalize this relationship, Smith wrote "realisation rules" that describe the process by which adult surface phonemic forms are realized as the forms Amahl produced, on the assumption that these rules are innate and come to be unlearned in development, potentially becoming optional along the way. The set of 26 rules that Smith supplies are subject to a strict order and are claimed to account for the totality of the data. In Smith's framework, a child is born with adult competence, diverging only in performance in the course of development.

The observations Smith (1973) made about Amahl's phonological system were not as clear-cut as he expected. His aim was to present analysis of the regularity found among child forms, but he observed the occurrence of (1) non-English sounds and sound sequences in the child's repertoire, (2) many exceptional forms, and (3) a many-many correspondence between segments (when comparing the child's to the adult system). In illustration of a many-many correspondence between segments, Table 2.1 shows a selection of Amahl's variants for /s/:

Table 2.1 Variants for /s/ in data for Amahl.

Realization of /s/	Target word	Child form
ø	'sun'	[ʌn]
[ġ]	'sock'	[ġɔk]
[t]	'mice'	[mait]
[ḅ]	'whistle'	[wiḅu]

(Data from Smith, 1973: 3)

Here Amahl produces [ġ] or omits the onset when targeting initial /s/, and produces [t] when targeting final /s/ and [b] when targeting medial /s/, although Smith does not address the position of /s/ in this portion of data.

A close look at a couple of these examples in context with the rules that apply to them is informative. Amahl's pronunciation of 'sun' [ʌn] was observed to alternate with [ḍʌn] as a result of Rule 9 where, in a word with the structure /sVC/, the /s/ is optionally deleted if the C is labial or alveolar (Smith, 1973: 16). Presumably, the realization of /s/ as [ḍ] is a result of Rule 24, which states that all non-sonorant consonants are non-continuant, non-strident, non-affricated and non-lateral (Smith, 1973: 21). This rule neutralizes /s/, as strident and non-sonorant, to |ḍ|[1]. Amahl's pronunciation of 'mouse' [mait] is cited as an exception to Rule 5, which states that a continuant consonant preceded by a nasal and a vowel becomes a nasal (Smith, 1973: 15). The rule begins with the clause "in some cases", and Smith (1973: 15) notes that there are "just as many cases where it does not apply as where it does". The variable production of a given segment is common in child data. Vihman and Croft (2007) point to this phenomenon as evidence for a child's use of whole-word patterns (i.e., templates), along with other behaviors, in early development, which are elaborated in Chapter 3.

Smith's (1973) rules satisfactorily account for many forms but leave others as exceptions lacking explanation. Smith's intent was to draw connections between child and adult target forms within a generative framework (Chomsky & Halle, 1968). In describing Amahl's incipient phonological system, he concludes that "although the child's performance was immediately accessible for observation, it was by no means self-

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[1] The vertical lines indicate a phoneme the child developed, in contrast with a phoneme that is part of adult English phonology.

evident what the nature of his phonological competence was” (1973:1). Two distinct analyses were undertaken: one that assumed the child’s competence and performance were equal, and one that assumed that the child’s competence was equal to the input from the adult language. Smith (1973: 5) concluded that only the latter is feasible, claiming that a majority of the data can be explained by the rules he constructed, but “only a fraction” of exceptional forms can be explained if the child is assumed to have an “autonomous” system.

Smith (1973) himself stressed that a theory of acquisition must be able to account for exceptional forms, but his account relying solely on rules leaves both exception and optionality. As Fikkert (2000) points out, studies attempting to solve the challenges of early child data by targeting segments in a rule-based account are outdated. Spencer (1986) offered a reanalysis of Amahl’s data using a non-linear psycholinguistic approach. Smith also argued that changes in Amahl’s system occurred in an across-the-board way: “It has frequently been observed that when a child learns to pronounce a new sound or combination of sounds he immediately utilises it correctly in all the relevant words, rather than adding it piecemeal to each word as he re-hears it after his new-found ability” (Smith, 1973: 138-139). Macken (1979), among others, provides evidence of changes that do not occur in this way. Rather a new rule or a process at first affects some words but not others; old pronunciations that are more deeply entrenched resist the new processes. Macken (1980) points out that this may in part be due to the fact that she studied children younger than Amahl, an observation which highlights the importance of studying phonological systems early in development in order to truly understand acquisition. Smith’s rigorously formalized analysis is, nonetheless, important because it offers a way to (1) begin to account for a large amount of a single child's data and (2) describe segmental correspondences between child and adult forms. Evidence shows that even in early development, when child forms are the most unruly, segment-based rules are descriptively sufficient for some forms (Macken, 1979; Menn & Matthei, 1992; Priestly, 1977/2013).

Systematicity in child phonological systems does not depend only on the relationship between child and adult forms, however. Systematic yet idiosyncratic patterns are commonly identified among child forms, which is suggestive of at least somewhat individualized paths of development (Ferguson & Farwell, 1975; Vihman, 1996; Vihman, Ferguson, & Elbert, 1986; Vihman & Greenlee, 1987). Smith (1973: 10) remarks that his study focuses only on the acquisition of phonology because he's not a trained psychologist and "[he] strongly suspect[s] that the general cognitive development of the child is not relevant…" This statement runs counter to the theoretical approach to development assumed in the present research. Indeed dynamic systems theory (Thelen & Smith, 1994) can offer explanation for both regularities and irregularities in a developing phonological system, and depends on variation to spur development (described in detail in Chapter 4). This point highlights the importance of the theoretical framework with which one approaches a set of data. The strength of a theoretical framework may be either supported or diminshed by a thoroughly documented set of data, and Smith's (1973) seminal study is a valuable resource in phonological acquisition research.

2.3.3 The relationship among child forms

Data collection for Amahl began too late in his development (at age 2;2) for inclusion in the present research. Smith (2010) later conducted a study of his grandson Zachary's developing phonological system, which includes a richly detailed appendix listing words the child produced, along with variant pronunciations. While data collection for Zachary began early enough in development—babbling was first documented at age 0;6, the data were ultimately excluded from the present analysis for practical reasons, involving disparity in the organization of data with the other studies used. Additionally, Zachary was the only British English-acquiring child among those whose data were examined. Excluding the data, furthermore, left a data set comprised only of American English-acquiring subjects whose data were more easily compared.

Smith's (2010) study of Zachary, nevertheless, directs attention to the important issue of the developmental point at which data collection for an acquisition study is initiated. Phonological systems documented earlier in development—e.g., at the onset of word production—exhibit patterns as challenging for analysis as they are informative to the developmental process. Analysis of data from studies that begin at the onset of word production (e.g., Vihman & Vihman, 2011) or even earlier in babbling (see Elbers & Ton, 1985; Stoel-Gammon, 1989; Vihman, DePaolis, & Keren-Portnoy, 2009; Vihman, Ferguson, & Elbert, 1986) is crucial. Babbling research in particular shows that the patterns in child pronunciation emerge out of a child's first vocalization attempts.

Seemingly noisy data from the onset of word production expose the inadequacy of a theory focused only on processes targeting segments. Analysis looking to relationships among a child's utterances, however, suggests that whole-word patterns function as the primary unit around which a first phonological system is constructed (Ferguson & Farwell, 1975/2013; Vihman & Wauquier, in press; Waterson, 1971). The two studies described in the following paragraphs point to data illustrating this phenomenon and highlight the value of the diary study in obtaining relevant contextual data. This sort of supplemental information a diary study tends to reap can aid our understanding of unusual forms produced for a given word and also enable the detection of patterns in an individual child's forms that might otherwise not be readily apparent.

2.3.3.1 Waterson (1971)

Waterson (1971) conducted a study of her eldest child P's developing phonological system. Data were collected daily, and in her records Waterson included rich observational detail from the time the child was a baby. As a baby, P was always engaged while awake and was spoken to frequently. He was never left inactive in his crib but rather physical activity and play time were encouraged. He began walking early, and also displayed a good memory and sense of humor early on. When he began to produce words, his vocabulary included names of people, animals and objects in his environment, and things in books and in his daily life. These details are relevant because a child is constantly exposed to input bearing details of the adult phonological system and because the linguistic development of a child is "conditioned" by that child's environment (Waterson, 1971: 180).

Waterson (1971) cautions that analysis of a child's early language data is specifically applicable only to that child, noting that more general patterns of development may be more broadly applicable. This point holds weight in view of a common criticism that diary studies provide insight about only one child. The significance of an individual child's environment in language development and the child-specific nature of data highlight the undeniable benefit of using data sets that offer rich contextual information for one or two children.

A primary aim of Waterson's (1971: 182) study was "…to see what correlations could be established at the phonetic and phonological levels and to determine how much of the adult form the child was producing". The way Waterson puts this idea into words places us in the perspective of the child rather than of the researcher attempting to make sense of child pronunciation relative to that of the adult. Indeed her primary aim is to provide evidence for the child's developing phonological system being independent from, but related to, the adult's system. As such, the child's system should not be interpreted through the adult's system but rather on its own terms. A child in the earliest stages of language development has limited tools with which to work, rendering him or her incapable of articulating the phonetic content of a word in accurately fine detail to match adult pronunciation. Waterson's aim as it is written above might be fine-tuned to add that we are looking not only at how much of the adult pronunciation is produced but what elements exactly are produced. This is essentially what Waterson's study does by describing features the child uses to produce words, and then uniting the child's forms into identifiable groups.

Close analysis of the detailed data and corresponding notes that Waterson provides illustrate the utility of a well-documented diary study. In order to analyze child forms in relationship to their adult targets, Waterson (1971: 183) organized the data into groups according to the dominant feature used in the word's composition, resulting in five groups: labial, continuant, sibilant, stop, and nasal. With the term “feature” Waterson (1971: 179-180) refers not to the universal features of generative theory, but rather to features that “arise from the material under investigation”, and more specifically the articulatory features “required to describe the particular forms of the child and adult at the time the child was 18 months old”. For example, P exhibited what Waterson describes as a Continuant Structure in the utterances in Table 2.2.

Table 2.2 P’s utterances demonstrating use of the sibilant structure.

Child form	Adult target word	Adult target form
[ah̤ɔ/æhɔ/aɦ̃ʷʊ̃]	‘angel’	[eĩndʒəʷɫ]
[ahʷɔ/æhɔ/aɦ̃ʷʊ̃]	‘hymn’	[hɪm]
[ahʷu]	‘honey’	[hʌnɪ]
[ẽɦ̃ẽ/hẽɦ̃ẽ]	‘Rooney’	[rʷũ:nĩ]

(Data adapted from Waterson, 1971: 190-191)

Notably, the adult target phonetic forms do not resemble each other very closely, but the child forms do. Waterson offers a semantic explanation for the homonymous forms for ‘angel’ and ‘hymn’, suggesting that, because P had a hymn-book with angels on the cover he likely did not semantically differentiate the two words. Describing [h] as a medial glottal continuant, Waterson (1971: 191) calls attention to the disyllabicity of both the child and adult forms and notes the child’s use of nasality over the entire form in connection with nasality in the adult forms. These qualities likely draw the child forms toward similarity in production.

While the correspondences between the child and adult forms above are unusual and somewhat unpredictable, they can be explained by way of patterns affecting the whole word in an idiosyncratically developing system. In child forms grouped in the other structures (e.g., nasal, labial, sibilant, stop) described, a similar convergence of forms is seen for phonetically dissimilar target words—a phenomenon that is discussed in more detail in an overview of templatic behavior in Chapter 3. Analysis of the Continuant Structure above demonstrates the utility of contextual information in the analysis of early phonological data. Details from the child's home life, provided by Waterson, P's linguist mother, offer a unique perspective on the development of otherwise unpredictable forms the child produced, emphasizing the importance of detail beyond linguistic structure that contributes to a developing phonological system.

2.3.3.2 Priestly (1977/2013)

Priestly (1977/2013: 217) began observing the production behavior of his son Christopher, only "sporadically" taking notes until he discerned systematicity in his son's utterances. At that point, Priestly accordingly took notes more systematically. The period for analysis covers 13 weeks when Christopher was aged 1;10.2 through 2;1.4. In organizing the data, Priestly separated words into "ordinary" words produced relatively accurately and "experimental" words produced inaccurately. Experimental words were divided into bisyllabic and monosyllabic forms. In a comprehensive list compiled during the 13-week period at the focus of the study, Priestly includes a list of 70 forms that Christopher produced, each of which use a medial-[j] pattern and corresponds to adult target words that do not use this pattern.

Priestly determined a series of what he called "equations" to describe the array of patterns the child used to produce the forms in which the [j]-medial pattern is seen. For example, one consisted of a sequence of an initial consonant and a post-tonic consonant in a target form, into which the child inserted [j] medially: $C_1 – C_{pt}$: C_1-j-C_{pt} (Priestly, 1977/2013: 220). As a result, Christopher produced [hajaŋ] when targeting the word ‘hanger’ [hæŋə]. Another equation entailed [j] being inserted between an initial consonant and a final consonant: C_1-C_f: C_1-j-C_f (Priestly, 1977/2013: 221). As a result, Christopher produced [rajat] when targeting the word *rabbit* [ræbɪt], replacing the target medial consonant [b] with [j].

In addition to forms produced systematically by way of the patterns he discerned, Priestly also observed “idiomatic” forms, whose adult target forms escape those inscribed by the equations. He suggests that the attractive force of the other [j]-medial forms in the child’s repertoire at the time—in addition to the influence of mistaken input resulting from confusion on the part of either the child or parent—resulted in these idiomatic forms also employing the pattern. For example, Christopher produced *chocolate* as [kajak]. The parents, then, often referred to chocolate as [kajæk], thereby influencing the child’s pronunciation. In another example, the child referred to his toy police-car as [pija], and at one point a parent mistakenly thought he was referencing a tube of toothpaste. Upon confusion in both parties, the form thereafter was used to refer to both the police-car and a tube of toothpaste. An abundance of data, accompanied by detailed note-taking beyond the data, enabled the author’s observation of the emergence of Christopher’s preferred [j]-medial pattern and, further, explanation for how phonetically disparate target words receive similar pronunciation.

A common criticism of diary studies is that their execution lacks systematicity. Priestly (1977/2013) points out that his study began modestly with little order in documentation until he noticed his child’s seemingly erratic forms in fact displayed patterns of interest. At that point, he began to more regularly and systematically document his son’s word production, facilitating the description of a detailed system of rules and strategies—idiosyncratic as it may be. While the methodology was initially approached with little systematicity, the analysis finds strength in highlighting a clear system of patterns in the data. Priestly's analysis, which emphasizes the relationships among child forms, emerges from the full spectrum of data made available by the diary nature of the study. Among both typical and exceptional forms, Priestly clearly identified a [j]-medial pattern affecting whole words in the child's production, rendering this study valuable as early evidence of templates (described in detail in Chapter 3). The equation system he proposed offers a data-driven technique for analysis better suited to describing some of the unusual patterns seen in child data, which escape segment-based rules. This is not to suggest that the equation system is appropriate for all data sets—or can cover all phenomena in an individual's data set, but rather to emphasize the utility of letting the data guide analysis and the importance of well-documented data with which to begin.

2.3.4 Acquisition norms and individual differences: Ferguson and Farwell (1975/2013)

Another criticism of diary studies, in addition to systematicity, is that because only one or two children is studied, analysis tells us nothing about acquisition norms. This criticism is fair since a single study in fact fails in this way, but data collected during a diary study can be useful in future analysis, provided that the methodology is clear and data are thorough and well-documented. There is a marked improvement in methodological clarity between Velten's (1943) and Smith's (1973) studies, and the CHILDES database (MacWhinney, 2000)—a valuable online collection of child language data in several languages—makes methodological details available. Access to details describing the way a study was conducted should help to level out methodological disparity across studies, fostering valid conclusions about acquisition norms.

Studies comparing diary data across children hold the potential to reveal both norms and points of divergence across children acquiring language, and to do so backed by substantial detail about individual paths of acquisition. Ferguson and Farwell's (1975/2013) seminal paper presents a study of first-word data from three children, two acquiring English and one acquiring both German and English. More structured than a traditional diary study, this study is a smaller part of a longitudinal study of first-language consonant acquisition in seven English-acquiring children. The study is included in this chapter about the tradition of diary studies because it demonstrates the value of a traditional diary study both on its own and in continued use for the purpose of comparing trends found in other studies. The two children whose data were part of the larger study (i.e., T and K) were visited weekly in their homes by one or two observers, who tape-recorded the session and took notes in coordination with the child's parents where clarification was needed. Data for the third subject, originally reported in Leopold's (1939-49) study of his daughter Hildegard, was included as a point of reference.

Unlike the other two children in the study, Hildegard was raised bilingual and experienced a disruption in her exposure to (and subsequently, comprehension of) English. In attempt to account for this difference, Ferguson and Farwell (1975/2013: 95) addressed only utterances that were still being used at the age during which the child went to Germany and traced their histories backward. Differences in methodology between the studies necessitate adjustment to the way in which data are considered in analysis. While there are clear drawbacks to this practice, the data itself and observational notes that accompany it are nonetheless valuable.

Ferguson and Farwell's (1975/2013) study is often referenced for a few notable conclusions about early phonological acquisition. One of these is that the children in the study exhibited a trend by which they produced fairly accurate forms for a given word early on, which they later produced less accurately as they acquired more knowledge. For example, the child K produced the utterances in (2) for the target *all gone*:

(2)	[əkʰo]	(Session I)[2]
	[ʔɑpʰɑ, ʔɑgu, ʔap]	(Session II)
	[ʔulɑ̃]	(Session VIII)
	[ʔaʊwᵊᵏʰ]	(Session IX)

(Data from Ferguson & Farwell, 1975/2013: 120-121)

The utterance in Session I is relatively accurate, and so is the second utterance in Session II, at least in terms of maintaining the basic phonological shape of the target word(s), but accuracy is lost across the sessions as the child acquires more linguistic knowledge. This is the case, also, for the other children studied.

As a relevant aside, because the utterances for T and K are reported in terms of sessions rather than by age, in contrast with Hildegard, whose utterances are reported in terms of age, direct comparison requires some effort. Ultimately, since it is paths of development in the acquisition of initial consonants that are being compared, the age at which an utterance is produced is not crucial since children begin producing words at

[2] The numbered sessions indicate the sequentially numbered week in which utterances were documented. Data collection for T began at age 0;11 and continued for 9 weekly sessions until 51 words were reached; data collection for K began at age 1;2 and continued for 13 weekly sessions until 72 words were reached. Leopold's (1939-39) study of Hildegard began when the child was aged 1;0 and continued for 6 months until 54 words were reached.

different age points and progress at different rates. Nevertheless, for the sake of comparability between studies, it would be advantageous for future studies organizing data by session to also include the child's age, and perhaps vice versa. With this, it would be further advantageous for researchers engaging in diary studies to document utterances to the exact day, as in Priestly (1977/2013; e.g., 1;2.4). Due to a lack of foresight about the potential use of the data, the diary study launching the present research documented utterances sequentially in a spreadsheet but organized data only by month. Future studies, particularly those concerned with the intricate and often idiosyncratic processes at the onset of word production, will benefit from such detailed documentation.

In contrast with Jakobson's (1941/1968) aim to capture generalizations about the order of acquisition, Ferguson and Farwell (1975/2013: 110) emphasize the reality of individual differences along paths of acquisition. Children exhibit different preferences for sounds or sound classes, for word production strategies, and for methods of dealing with challenging sounds, and these preferences bear relationship with the words that children choose to target for production. For example, the child T exhibits a preference for sibilant fricatives and affricates and attempts to produces target words containing these sounds. Hildegard early on attended to words with initial target /b/, /m/, /d/, and /ʔ/, while T focused on producing words with initial velar stops. Interestingly, Ferguson and Farwell (1975/2013: 95) observed that each of the children showed different tendencies toward imitation: neither T nor Hildegard were included to imitate much, but K imitated "almost any word beginning with a sound at least close to one she could say". This point is of interest given the importance of frequency effects in phonological acquisition (Menn et al., 2013) and the role of vocal motor practice (McCune & Vihman, 1987) in the establishment of a phonological system.

Ferguson and Farwell (1975/2013: 112) meticulously mapped out the occurrence of phone classes, which the authors liken to the traditional idea of a phoneme, in what they call phone trees. The purpose was to trace the emergence of corresponding phones in initial consonant position. For example, during a particular session, T produced the phone class presented in (3) in words with initial target [b]:

(3) [b ~ β ~ bw ~ p^h ~ Φ ~ θ]

(Data from Ferguson & Farwell, 1975/2013: 99)

That is, for a word with a target initial consonant [b], T produced any one of these variants; interestingly, previously defined phone classes like this one differed in subsequent sessions. The phone trees were intended to determine, given definite lexical items, which sounds (i.e., or phone classes) were contrastive in the child's repertoire and how contrasts changed, and also to determine the behavioral unit in the development of a phonological system. The authors conclude that "children learn words from other [word]s, construct their own phonologies, and gradually develop phonological awareness" (Ferguson & Farwell, 1975/2013: 112). They point out that particular word shapes seem to be acquired together, thus rendering the study foundational to the templatic approach to early phonological acquisition. This study also illustrates the utility of richly documented diary data toward beginning to make more general claims about the processes of early phonological acquisition.

2.4 The pros and cons of the diary study

The content up to this point in the chapter stresses the capacity of diary studies to reap valuable acquisition data, but criticisms of the diary study on the whole are not unwarranted. Diary studies by nature focus on only one or two children, in some cases suffer from unsystematic data collection, and bear the risk of imprecision in transcription. Each of these potential disadvantages can be addressed, however, and are ultimately worth facing in light of the advantages of procuring well-documented data with which to work.

Especially when conducted by a linguistically trained parent of the child, a diary study can be the best way to obtain richly detailed contextual information that may necessarily be missing from longitudinal studies conducted in a laboratory and even those conducted in the child’s home environment with intervals of time between visits. The studies described above illustrate the range of analyses to which diary study data have effectively availed themselves. Velten (1943) presents data illustrating the order in which her subject produced particular sounds, providing analysis of the way each new sound affected the child’s repertoire on the whole. Smith (1973) provides rigorous formalized analysis of a single child’s data, beginning at age 2;2, with focus on the relationship between child and adult forms. Waterson (1971) and Priestly (1977/2013) offer analysis of data from the very early stages of word production, illustrating the importance of relationships among an individual child’s words. They, furthermore, demonstrate the enrichment of analysis that contextual notes bring to the phonetic transcription of a child’s utterances.

Ferguson and Farwell (1975/2013) employ diary data from an older study as a point of reference in conjunction with current data from two other children, providing evidence of individual differences in paths of acquisition. They, furthermore, draw attention to methodological issues that can surface when data from different studies are employed in a single project. Priestly (1977/2013) acknowledged that he did not begin documenting his child's production behavior with any systematicity, but rather that the project began as simple note-taking out of a linguist-parent's curiosity. Fortunate accidents like this are instructive for developing more firmly established methodology for future diary studies. In accordance with the focus of an intended study—for example, to investigate behaviors at the onset of word production, in babbling, or later in development—methodology can be fairly well defined ahead of time based on the successes and missteps of previous studies. In particular, decisions must be made about the criteria for documenting utterances, the notation for documenting the age at which utterances are produced, and whether and how to employ audio or video recordings.

This said, however, some degree of flexibility should be built into a diary study. Early phonological data is given to rapidly changing organization, as evidenced by changes in utterance accuracy from stage to stage in a given child. Also, methodology may require adjustment depending on the child's needs and on the practical considerations of the researcher. Ideally, a researcher can be present a majority of the time in order to capture the majority of a child's utterances, enabling close tracking of variant pronunciations and slowly changing patterns. Ideally, recordings will be made for the purpose of supplementary acoustic analysis and transcription validation. Since the subject of an acquisition study is a baby—a human being who requires considerable attention and may respond disfavorably to constant note-taking or the presence of recording equipment, flexibility is necessary. Ideals may need to be compromised to some degree. The benefits of a richly detailed corpus of child data, which a diary study is capable of providing, outweigh the limitation of wavering systematicity in data collection, as long as the methodology—and divergence from it—is clearly articulated. Furthermore, in order to answer challenges to another issue concerning the reliability of a researcher's transcription notes, measures should be taken (e.g., by way of a recording and sample transcription by another trained linguist) and made explicit to eliminate uncertainty about the quality of transcription.

The present research builds on a strong tradition of diary studies in acquisition research and is interested in the detailed process of the acquisition of sounds and sound patterns, emphasizing varying degrees of abstraction with each newly produced utterance. These aims require access to very detailed data, which a diary study can provide. The study at the center of the present research (i.e., Djuna), like Vihman and Vihman's (2011) study of Maarja, examines templatic behavior beginning at the onset of word production. Additional studies were referenced in the study of Djuna's development for issues concerning whether or not to include imitated utterances and data documentation and organization (e.g., Ferguson & Farwell, 1975/2013; Macken, 1979; Menn, 1971; Smith, 1973). A detailed description of the methodology is described—for data collected from Djuna and also the other children whose data were analyzed for this research—in Chapter 6. While the present researcher has linguistic training, a reliability measure for phonetic transcription was performed: another trained linguist was asked to transcribe a portion of a recording of the child's speech, and the transcription was compared with that of the researcher. Transcription data from the other studies employed here do not come with this assurance but are supported by the esteemed reputation of their authors within the field: *Charlotte*: Barbara L. Davis, *E*: Sharon Inkelas, and *Trevor*: A. J. Compton (complete references for associated studies are given in Chapter 6). Finally, while a study of four children cannot make firm claims about acquisition norms, an attempt is made to draw conclusions about general patterns while observing individual differences that emerge.

While this chapter aims to illustrate the value in diary studies, it does not intend to argue for their superiority over laboratory or large-sample longitudinal studies. Different types of studies, which elicit different ranges of data, all contribute to more complete knowledge of the processes involved with language acquisition. The use of audio and video recording, for example, can complement what we are able to learn from diary studies, whether session recordings or something more large-scale. The latter is made possible by a language environment analysis (LENA) device (Ford et al., 2009), worn in a child's clothing, which has been used to record large amounts of environmental data contributing to the child's language development. There are both benefits and limitations to any methodology. Together a variety of methods inform the construction of an accurate theoretical model of child language development. As long as the methodology is made absolutely clear, diary studies provide invaluably rich data sets. A thoroughly documented diary study potentially supplies not only its researcher—but also future researchers—with phonological, lexical, and contextual data particularly useful in studies targeting the onset of word production, which might not otherwise be obtained.

Chapter 3: Templatic representation in phonological acquisition

3.1 Introduction

Evidence of whole-word patterns in data collected during early phonological development (e.g., Ferguson & Farwell, 1975/2013; Macken, 1979; Menn, 1971; Priestly, 1977/2013; Vihman, 1996; Waterson, 1971) provides a foundation from which Vihman and Croft (2007) construct a templatic approach to representation. In this approach, a phonological system emerges by way of use, developing dynamically by way of its own activity. Whole-word shapes (i.e., templates) develop, based in a child's experience with the ambient language and his or her own production behaviors, as the first representational unit around which a phonological system is organized. As such, the templatic framework is capable of describing individual paths of development and accounting for variability in production both within and across children.

3.2 What is a template?

In order to flesh out the details of the templatic framework, it is crucial to first make clear the nature of a template. The template at the center of this approach is distinguished from that familiar to phonologists and those knowledgeable about the structure of Arabic and similar languages. Arabic has morphological roots typically comprised of a fixed-ordered set of consonants, which do not vary with the insertion of vowels or consonants for the purpose of deriving grammatical meaning (McCarthy & Prince, 1990; Ryding, 2005). Ryding (2005) suggests Arabic roots can be thought of as semantic fields since a root—or template—serves as the semantic base that contributes to the form of the word resulting from a morphological process. In fact, Arabic dictionaries are organized by lexical roots rather than by spelling, and for each entry a list of words derived from the root is included (Ryding, 2005: 49). An example of the root-pattern structure of Arabic words is given in (1):

(1) Arabic Form 2 (faṣla)

/ktb/	/drs/	/ʔlm/	/sm/	
"write"	"study"	"know"	"poison"	
kattab	*darras*	*ʔarram*	*sammam*	perfect active
kuttib	*durris*	*ʔullim*	*summim*	perfect passive
kattib	*darris*	*ʔallim*	*sammim*	imperfect active
kattab	*darras*	*ʔallam*	*sammam*	imperfect passive

(Data adapted from McCarthy & Prince, 1990: 2)

Templatic roots are given in phonemic brackets, followed in the column by a gloss and four derivations, in order from top to bottom: perfect active, perfect passive, imperfect active, and imperfect passive. Looking across each row from left to right, the inserted pattern associated with each derivation can be seen. The consonantal sequence associated with each root does not vary; only the inserted patterns vary, and they do so systematically.

The templates at the center of the approach to phonological acquisition, which form the backbone of the present study, are quite different. They are flexible, fleeting, and often idiosyncratic patterns used by children in the early acquisition process in order to facilitate word production. They do not function systematically across a community of speakers of a language, like the templatic morphology of Arabic. While they may be described as "established" or "routinized" at a given point in time, it is important that these descriptors not be misunderstood. Templatic patterns become established and routinized, but only such that a child uses them with some degree of systematicity for a brief period of time until they change in response to the child's experience with the language or disappear from use altogether. The apparent establishment of routine patterns is only illusorily stable, an idea explored in greater detail in terms of dynamic systems theory in Chapter 4.

If we look up the word 'template' in the dictionary, definitions like 'mold', 'pattern', 'model', and 'guide' appear. As synonyms, these words suggest that a template is fixed. A predesigned document containing a greeting, certain stock phrases, and a sign-off for use as a business letter might come to mind. The template in the approach described here can be thought of, rather, as a pattern and a guide, but it is not a rigid form with any permanence for perpetual use. In contrast with the lexical roots of Arabic, there is no semantic core linking words in a child's language that are produced with a given pattern. Rather a child develops phonological templates out of prelinguistic sounds and uses them to target phonetically similar words for production. Waterson (1971), discussed in more detail later in this chapter, explicitly shows how phonological features, and not semantic content, are at the center of developmental templates. For example, the child P uses homonymous forms for the adult targets 'bucket' [bʌkɪt] and 'Bobby' [bɔbɪ]: [bæbu:]. Waterson points out that the homonymous forms develop not because of any semantic relation that the child detects between the two but rather because the two words have features in common, attracting the use of what she names a Stop Structure. These features include disyllabic structure, voiced bilabial stop syllable onset, and voiced syllable ending (1971: 194). Further distinguishing templatic morphology from developmental templates, a child may also use different templates to produce a given word. Evidence of this phenomenon is described in Chapter 7 in reference to data collected for the present research.

3.3 How is a template identified?

Some criteria for identifying templates in a set of child data have recently been laid out in both Vihman (2016: 3) and Kehoe (2015: 98-99). Quantification confirming the presence of a template in a child's developing phonology has been defined such that a given pattern is present in a minimum of 10% of data sampled (Kehoe, 2015; Vihman, 2016); this measure was used in the present study. Qualitatively, evidence of templates is seen in the consistency of certain patterns in a child's words over a period of time, in unusual segmental correspondences that are not explicable by segment-based rules, and in a sharp increase in words using templates (Vihman & Croft, 2007: 694-695). More broadly, a template can be identified by its overuse (Vihman, 2016), particularly when compared with other children learning the same language or languages (Kehoe, 2015; Vihman & Velleman, 2000).

Templates may be somewhat generally defined. Consonant harmony is a common whole-word process seen in child data, which is common among children, although not universal (Vihman, 1978). In this process, non-sequential consonants assimilate in at least one feature; often this feature is one of place. Another more general template is found in Jaeger (1997), in which a fronting constraint involving labial-alveopalatal, labial-velar, and alveopalatal-velar consonant sequences is reported. Use of this template often results in metathesis; for example, when the child targets words in which a labial consonant occurs after an alveolar, the reverse order is produced. Examples of utterances using this process are given in (2), produced at age 1;10.15–1;11.10:

(2)	*TV*	[pití]
	sheep	[piɕ]
	sweep	[piɕ]
	David	[pita]
	soup	[puɕ]

(Data from Jaeger, 1997: 14)

Each of these examples results in metathesis of the target consonant sequence; the child also produced [tʌmp] for *jump* and [tʌmi] for *dummy*, ignoring the fronting constraint. Nevertheless, the fronting constraint saw dominant usage overall during this period, and the child's forms for a variety of words came to sound similar to one another. Vihman and Croft (2007: 701) suggest the exceptions to the constraint were due to entrenchment owing to the words being among the first the child produced and repeated often. It is fairly common for old forms to remain among new forms as a phonological system becomes more complex (see Macken, 1979; Oliveira-Guimarães, 2013).

Templates may also be more specific. For example, some studies report a consonant harmony process specified for place of articulation (Pater & Werle, 2001: velar harmony; Shaw, 1991: coronal harmony). Vihman and Vihman (2011: 113) describe a palatal template, specifically defined as "all words in which at least one syllable has as its nucleus a front-rising diphthong <Vɪ> or the tense vowel [i]". For example, the child in their study produced both [beɪ] and [bi:] for *bib* and [baɪ] for *bath*, and out of 111 word forms targeting the first 50 words, 53% were built on this palatal template (Vihman & Vihman, 2011: 114). Priestly (1977/2013) identified a [j]-medial template used in distinct ways, for which he wrote a series of "equations" to describe an emerging systematization in the child Christopher's phonology. For example, one use of the template involved a sequence of an initial consonant and a post-tonic consonant in a target form, into which the child inserted [j] medially: $C_1 – C_{pt}$: C_1-j-C_{pt} (Priestly, 1977/2013: 220). In this construction, targeting the word *hanger* [hæŋə], the child produced [hajaŋ]. Another use of the [j]-medial template involved [j] being inserted between an initial consonant and a final consonant: C_1-C_f: C_1-j-C_f (Priestly, 1977/2013: 221). Targeting the word *rabbit* [ræbɪt], the child produced [rajat]; in this case, [j] replaced the target medial consonant [b]. Priestly described other equations in addition to these, also used systematically in the child's developing phonology.

Two distinct kinds of template use have been observed (Vihman & Velleman, 2000), which define how templates are used initially to target words for production and then extended to new words. The first is selected use, in which the child uses an established whole-word pattern extracted from the phonotactics of the ambient language to target the production of a phonetically similar word—one that contains the phonological elements of the template. Vihman and Velleman (2000: 263) describe this process of selection as a consequence of the child's "implicit mapping of perceived word forms onto his or her existing production". By way of this process, the child's own production patterns guide the selection of words chosen for production. Selected template use tends to result in relatively accurate production, with some room for error in the production of a word, where it is not specified by the template. Templates are schematic structures loosely specified to allow for variation in the child's form but without altering the core structure of the template. For example, a child in Vihman and Velleman's (2000: 263) study produced [kuk^{h}ka] and [kuk:o] for /kuk:a/ *flower* in Finnish at age 1;1.10. The child in Jaeger's (1997) study produced [píki] for *piggy* and [pak^h] for *frog*. These utterances are representative of selected template use. Each is a fairly accurate estimation of the target pronunciation, with allowable variation in the production of vowels. Omission of [r] from the consonant cluster and voicing from the initial labial consonant are common errors in child speech and still allow for fairly accurate production.

Adapted use is the other kind of templatic process observed in pronunciation. In this kind of use, the child employs a template to target for production words that are only partially similar in their phonetic content, which tends to result in less accurate production. This is because the child uses a template of schematically specified phonological detail to attempt the production of a word that does not match that detail. Adapted use of a template might result in consonant omission, syllable omission, or consonant harmony, among other errors relative to targets (Vihman & Velleman, 2000). Waterson (1971: 190) observed that a pattern used by P (i.e., the Labial Structure) at age 1;6 had been "expanded to accommodate a wider range of forms" than at age 1;5, incorporating stop, rounding, and backness features. For example, the child's pronunciation of *barrow* at the earlier age was [wæwæ] and at the later age [bʌwʊ]; in the later pronunciation we see the stop feature in the initial consonant, backness features in the two vowels, and rounding in the second vowel. In this way, the child uses the template to facilitate word production and increase lexicon size. Waterson (1971) suggests that this behavior is a result of advances in perceptual abilities, which are then seen in production abilities.

In another example, a child in Vihman and Velleman's (2000: 263) study produced [pop:u] for /lop:u/ 'end, finished, all done' in Finnish. The child applied a consonant harmony process, replacing the initial /l/ with [p]. Vihman (1978) suggested that the articulatory redundancy phonetically simplifies a word and provides a mnemonic device for the child during the early period of word production when the lexicon is rapidly growing in size. She more specifically proposed that consonant harmony allows children to "focus on new segments or extra syllables by reducing the overall complexity of the word" (Vihman, 1978: 281). We might say that templates on the whole serve these functions. An example of adapted template use in Priestly (1977/2013: 235) illustrates another common phenomenon in early child speech—homonymy (Ingram, 1975; Lleó, 1990; Priestly, 1980; Tervoort, 1969; Waterson, 1971). The child used the form [pajat] for both *parrot* and *powder*. In the first case, it appears the child substitutes the glide [j] for the liquid [l], which Priestly (1977/2013) notes is a process concurrent with template use. In fact, he suggests that this substitution process may be the source of the [j]-medial template's formation. The use of the template to produce *powder* can be described as adapted use, wherein the template is extended to a phonetically dissimilar word, imposed as a whole-word process rather than one of segmental substitution.

The shift from when a child uses a template to select phonetically similar words for production to when a child begins adapting a template to produce words that are less phonetically similar can be viewed as the beginning of the construction of a phonological system (Vihman & Velleman, 2000). The resulting decrease in the accuracy of pronunciation relative to adult target forms tends to be accompanied by an increase in the number of words using templates and marks the onset of systematization in a child's phonological system (Vihman, Velleman, & McCune, 1994). For example, among the first 10 utterances, Djuna (whose data are discussed in detail in Chapter 7) produced the utterances in (3) for the target word *peek*:

(3) [pɪka]
[bɪka]
[pɪk]

These are the fifth, sixth, and seventh documented utterances after the onset of word production, and use a pattern described as a labial-velar template, in which the first singleton consonant in an utterance is labial and the second is velar. This pattern is used to produce other utterances during the first month of word production, during which time most utterances are characterized as selected use. In Djuna's tenth utterance, she produces [bʌku] for *bubble*, after having produced [ba] for *bubble* in the ninth utterance. This use of the template is characterized as adapted since the target word does not contain the labial-velar consonant pattern in the template. That is, the child extends the template to produce a partially phonetically dissimilar word. In this example, we can point to the use of the labial-velar template to produce *bubble* as a step in the construction of an abstract phonological system as the child generalizes a pattern familiar to her to produce a word whose phonetic contents deviate from the pattern. With this particular template for this particular child, an increase in words using the template is seen—but not the expected decrease in accuracy among words using the template. The template is exceptionally fleeting and scarcely used beyond the first month of word production.

While adapted template use allows us to see phonetic material in the transition to a more abstract unit of language, the selected use of a template is involved with initially establishing its emerging contours. Oliveira-Guimarães (2013: 297) points out that a crucial role of selected templatic processes lies in giving a template its shape. For example, in her study of Gabriel, acquiring Brazilian Portuguese, the author reports an emerging reduplication template ($C_1V_1C_1V_1$). Before extending the template in adapted use, the child selected for production *bebê* 'baby' [beˈbe] and *vovó* 'grandma' [vɔˈvɔ]. Each of these target words is disyllabic, consisting of a reduplicated syllable. A different set of consonants and vowels compose each of the target words, contributing to a more general reduplicated CV syllable rather than a pattern specified for a particular consonant or vowel. The generalization of the pattern in this way suggests a process of abstraction in its inception. This process becomes more clear when the template is extended in adapted use for the production of phonetically dissimilar words, like [beˈbe] for *Gabriel* /gabɾiˈɛw/ and [duˈdu] for *Pedro* /ˈpedɾu/. Notably, in addition to the CV pattern being reduplicated for the production of *Pedro*, we can see that the iambic stress pattern of the template was also imposed. Closely following a single template illustrates the processes of formation and representational use quite clearly. It is important to remember, though, that very quickly a child begins to work with a larger and increasingly varied repertoire of phonological material, and multiple templates may be in use at the same time. With this, multiple points of entry into the construction of an abstract phonological system can be observed.

To further clarify the way that these two kinds of template use should be understood, selected and adapted uses do not correspond to developmental stages. That is, it is not the case that a child uses a template in a selected way in early development, targeting words for production that match the template, and then later adapts that template to phonetically dissimilar words. It is typically the case, however, that a child will exhibit selected use of a template before adapted use, and then both kinds of use can occur contemporaneously, and this may be the case for multiple templates simultaneously. This happens because a child does not randomly compose a template for the purpose of word production. The child has neither the phonological tools nor cognitive capacity to do so. Rather, the child builds a template from a place of motoric familiarity with certain sounds (McCune & Vihman, 2001), of phonetic grounding in certain sounds, and an articulatory filter sensitive to certain sounds (Vihman, 1993). These phenomena, discussed below, are supported by research on babbling.

3.4 The relationship between templates and babbling

Vihman and Wauquier (in press: 1), describe templates as "child-specific phonological patterns or emergent neuromotor routines that lead to increasing *similarity among the child's early word forms* – often at the *expense of accuracy*" (italics in original). In contrast with the claim that no relationship exists between babbling and first words (Jakobson, 1941/1968), templates in child language are borne out of patterns of motoric behavior in coordination with developing cognitive abilities associated with language (McCune & Vihman, 2001). Before children establish what have been described as "little word groups" or "schemas" (Waterson, 1971), "preferred word patterns" (Macken, 1979), "word recipes" (Vihman & Velleman, 1989), and eventually templates (Vihman, 1993; 1996), they tend to exhibit a preference for certain sounds in their babbling repertoire that influence the first meaningful words they produce (Cruttenden, 1970; Elbers & Ton, 1985; Jaeger, 1997; Macken, 1979; McCune & Vihman, 1987).

Babbling behavior warrants attention in the development of a phonological system. While babbling is often thought of as a developmental stage that precedes first words, it does not abruptly end at the initiation of first words. Rather late-stage babbling is concurrent with a child's initiation of first words (Locke, 1983). Locke and Pearson (1992) suggest that babbling stimulates brain growth necessary for vocal learning. Dynamic systems theory demands that the development of linguistic structure be understood in the context of development across the domains of a whole organism (Thelen & Smith, 1994). Up to about age 0;6, the infant vocal apparatus gradually changes from one comprised of a small mouth, large tongue, and limited mobility of the lips, to one more suitable for coordinated articulatory movements (Thelen et al., 1991). Concurrent with the emergence of rhythmic limb movement (Thelen, 1981), infants begin babbling around age 0;6–0;7. Thelen (1981) proposes that rhythmic patterns—like those we see in infant limb motion and babbling—are adaptive behaviors that lay the foundation for more skilled behavior. Such patterns are generated early in life, only some of which will be retained dependent on their utility (Thelen et al., 1991), which offers some explanation for why we see templates emerge and then disappear from a child's production. Jaeger (1997: 26) describes a template (e.g., [CVCˈN̩]) having emerged from a child's babbling patterns and observed that, as the child's forms came to more closely match adult target forms, those using the template "were extinguished". Indeed there is additional evidence for this phenomenon (Macken, 1979; Oliveira-Guimarães, 2013; Priestly, 1977/2013).

A child's active participation in the production of speech sounds, in addition to his or her ability to perceive phonetic information in the input, is a source for phonetic learning (Locke & Pearson, 1992). There is no discrete discontinuity between the babbling stage and first words. Rather, the sounds of babbling directly impact the sounds present in first words (see Elbers & Ton, 1985; Stoel-Gammon, 1989; Vihman, DePaolis,

& Keren-Portnoy, 2009; Vihman, Ferguson, & Elbert, 1986) and contribute to the routinizing of phonetic patterns in the child's incipient repertoire (Vihman, 1993). A child's first words tend to contain the sounds that the child has become proficient at producing prelinguistically (Schwartz & Leonard, 1982; Vihman & McCune, 1987). The concepts of vocal motor schemes (Vihman & McCune, 1987) and an articulatory filter (Vihman, 1993) facilitate a more nuanced understanding of how this might happen.

By about age 0;10, individual differences begin to surface in production as children develop preferred vocal patterns in response to the ambient language (Vihman, Velleman, & McCune, 1994). Vihman and McCune (1987) found that this limited set of prelinguistic sounds, which they call a vocal motor scheme, tends to dominate a child's vocalizations. The consonants produced in the first words in each of 20 children they studied were based on those in each child's specific vocal motor schemes (McCune & Vihman, 2001: 678). For example, many of the children studied displayed a preference for [t/d] and [p/b], while some of the others preferred [k/g], [s], [m], [n], and [l] (McCune & Vihman, 2001: 676). Vocal motor schemes vary from child to child (Vihman & McCune, 1987), thus setting each child on an individualized developmental path, and constitute a bridge between phonetic beginnings in early speech to an abstract phonological system (Vihman, Velleman, & McCune, 1994). Following the logic in Thelen et al. (1991), vocal motor schemes serve as adaptive speech behaviors that lay the foundation for meaningful language seen in first words.

The sounds of a child's vocal motor schemes occur in a preponderance of phonetically similar first words targeted for production by way of a proposed articulatory filter (Vihman, 1993). Vihman (1993) suggests that a child's vocal motor schemes give rise to a "phonetic template" unique to each child that makes salient the sounds in adult language to which a child is exposed. She calls this mechanism an articulatory filter. Guided by the phonetic details of the articulatory filter, children attend to the sounds of their own vocal patterns and the articulatory gestures associated with them. Vihman compares the articulatory filter to Waterson's (1971: 206) conception of a schema, which a child extracts by way of recognition of a selection of phonetic features in the words or utterances to which he or she is exposed. This results in the production of the same type of structure, and every word or utterance has a schema. Waterson (1971: 198) suggests, further, that a child reproduces what is perceived most clearly, namely sounds already in the child's repertoire, or strongly articulated features that are reinforced in the utterance. For example, the child P in Waterson's study developed a Nasal Structure defined by a set of basic features[1] including nasality, voiced onset syllable onset, and prominence of the first syllable (1971: 187). P also used Labial, Continuant, Sibilant, and Stop structures, and it is the set of basic features drawing together words of a given structure that serve to differentiate one structure from another. Ostensibly, a child recognizes certain basic features in words in the input, and also recognizes differences in the form of a given structure. This results in a similar shape across the word but with differences, as in (4):

(4)		*finger*	*window*	*another*	*Randall*
	1;6	[ɲẽːɲẽ/ɲiːɲɪ]	[ɲeːɲe]	[ɲaɲa]	[ɲaɲø]

(Data from Waterson, 1971: 187)

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[1] The features to which Waterson (1971: 179) refers are not the universal features of generative theory; they "arise from the material under investigation". More specifically, they are the articulatory features "required to describe the particular forms of the child and adult at the time the child was 18 months old" (Waterson, 1971: 179-180).

In this example, the utterances are grouped together by features representative of the Nasal Structure, including nasality and prominence of the first syllable, and differences between them occur in the vowels.

If, as Waterson (1971) notes, schemas are built up from the input, and even children acquiring the same language will be exposed to different input, their phonological systems will be built differently upon phonological categories from early production patterns. In this way, templates cannot be innate, which Vihman and Croft (2007: 707) point out supports an emergent theory of development. Templates are not typically present in first words but rather develop by way of the phonological information that a child uses and experiences prelinguistically in the earliest stages of word production.

Connecting these concepts to perception helps to provide a more comprehensive understanding of how a child's early production abilities emerge in connection with his or her processing of linguistic input. The articulatory filter plays an important role in guiding what words a child attempts to produce, reinforcing sounds with which a child is familiar, while allowing wiggle room to extend the child's repertoire of sounds beyond that of established schematic patterns. At first, however, a child tends to produce relatively accurate forms (Ferguson & Farwell, 1975/2013), and it has been argued that this is due to a production-perception loop in which the articulatory filter participates (Vihman, DePaolis, & Keren-Portnoy, 2009). Vihman, DePaolis, & Keren-Portnoy (2009: 169) present a diagram illustrating the articulatory filter as a "cross-modal mapping of production onto perception". In the diagram a child's vocal patterns are repeated and reinforced by the saliency of words in the input containing these patterns and word forms similar to the child's vocal pattern used repeatedly in routine situations, resulting in relatively accurate production of a word containing this pattern. Production and perception processes continuously feed into each other, reinforcing both the patterns a child produces and those perceived in the input.

Taking a step back, it is helpful to consider how a child might initiate the sounds of his or her babbling in the first place. Because a child in the process of acquiring the phonological system of his or her ambient language cannot see the coordinated articulatory movements involved in another person producing speech, audition is crucial (Kuhl & Meltzoff, 1988). Infants imitate the sound patterns detected in their ambient language, and Kuhl and Meltzoff (1988: 254) describe the way that infants are able to do this: first, infants make an auditory-auditory match, imitating and comparing what they hear another person produce and what they themselves produce; then, they begin to develop auditory-articulatory mapping, linking what they hear to attempt to match it in production. These behaviors begin before a child initiates babbling. By the process of imitating and comparing sounds in audition and production, infants begin to acquire the articulatory skill required for producing the sounds of the language to which they are exposed. Influences of the ambient language on babbling and early word production include effects on prosody, vowel space, and the place of articulation of consonants, and at this point individual differences are seen, which tend to dissolve as children attain finer-detailed knowledge of the ambient language (Vihman & Boysson-Bardies, 1994).

The present research closely examines the process of phonological development at the onset of word production in order to follow the path from the sounds produced in first words to patterns developing in a phonological system, with a focus on template use.

McCune (2013) notes that templates provide a window into the processes involved in acquiring a first phonological system. Babbling provides a window into the motor patterns involved in the formation of first templates. While the present research does not focus its investigation on babbling patterns, recognition of the continuity between babbling and early word forms—and the mechanisms guiding the development from one to the other—is essential to fully grasping the impetus for, and the role of, templatic representation in phonological acquisition.

3.5 Evidence for templatic behavior

An advantage of templatic analysis of early child production data lies in its ability to capture emerging systematicity in a child's first words, which cannot be captured by segment-based rules or constraints relying on the relationship between child and target adult pronunciations, at least not without ignoring exceptional forms. Exceptional forms in a child's data can be especially informative. The templatic approach can make sense of forms left unexplained by traditional analyses, and additionally can offer explanation for phonological processes seen in child, but rarely adult, forms (e.g., consonant harmony, metathesis, velar fronting), with which traditional theories have struggled. Observations of variation in the production of segments, of the relationships among an individual child's words, and of the relationships (or lack thereof) between child and adult forms, serve as evidence for templates.

3.5.1 Variation in the production of segments

In laying out their approach to templatic representation, Vihman & Croft (2007: 714) highlight a child's aim to produce words rather than to learn individual sounds in the process of acquiring a language. This may seem like an obvious point, but drawing attention to it is important in the context of phonological development. Acknowledging the importance of input, Waterson (1971: 181) points out that when a child's pronunciation is encouraged, corrected, or reinforced, it is in terms of a whole word or utterance and typically not focused on a segment. Furthermore, a child in the process of acquiring a phonological system fine-tunes knowledge of individual sounds and their nuanced phonetic detail as they are positioned within a phonetic context in the meaningful words that he or she targets (Vihman & Croft, 2007).

In their analysis of the acquisition of initial consonants in three children, Ferguson & Farwell (1975/2013) establish phone classes for each child by grouping together phones (i.e., initial consonant variants) used to target the production of a word. Some phone classes are simple, like one for the child T consisting of only two variants, [d] and [t^h] (Ferguson & Farwell, 1975/2013: 98), including utterances for *thank you* [dɑt^{h}ɑ, t^{h}ædju], *daddy* [dæt^{h}i, dædæʔ], and *bye-bye* [dæ bæ] (Ferguson & Farwell, 1975/2013: 125). Other phone classes are more expansive, like one in a later session for the child T consisting of several variants, [b, β, bw, p^h, Φ, ø] (Ferguson & Farwell, 1975/2013: 99), for pronunciations of *baby*, *bounce*, *bye-bye*, *paper*, *blanket*, *ball*, and *book* (Ferguson & Farwell, 1975/2013: 125). While variants have been observed for a single sound in a given word, some target sounds are produced differently in different words. For example, in Vihman and Velleman (1989: 157), the child Molly produced [w] targeting the initial

/w/ in *walk*, but [h] targeting the initial /w/ in *work* during the same period of time (age 1;3.24). Looking at word-final consonants, Molly produced [hʌpʰ] for *oops* (age 1;0.10) and [kʌkʰ] for *cup* (1;0.26) (Vihman & Velleman, 1989: 156), relying on a consonant harmony strategy for her pronunciation of *cup*. These examples provide evidence that children learn the phontactics of the ambient language by way of their phonetic context within the bounds of individual words. By extracting word-defined patterns, a child begins to acquire abstract knowledge of the language.

Bybee (2001: 88) proposes the possibility that phonological representation may consist of sets of "mutually exclusive" syllable onsets, nuclei, and codas as a result of phonetic differences between realizations of what is often assumed to be a phoneme as it is produced in different syllabic positions. She gives the example of [l] and [p] in the English words *leap* and *peal*, the first in which [l] is the onset and the second in which [l] is the coda, and the reverse for [p]. According to Bybee (2001), phonetic differences arise between each of these sounds in onset and coda position—differences that become greater over time. She suggests that rather than positing that each of these phonetically dissimilar but related sounds derives from the same phoneme, it may be that each of these sounds is represented distinctly in onset and in coda positions, and likewise for all consonants in a language.

This proposal is tenable in view of children acquiring phonology by way of the sounds they attend to in word-shaped patterns (Macken, 1979; Velleman & Vihman, 2002; Vihman & Croft, 2007; Waterson, 1971), as guided by prelinguistic vocal patterns (McCune & Vihman, 1987). If children proceed from auditory-auditory to auditory-articulatory mapping, as Kuhl & Meltzoff (1988) propose, the phonetic differences between a consonant in onset position and its realization in coda position are significant as a child builds up phonological categories. Templates are defined by the position of certain phonological elements within a word (e.g., fronting constraint on consonant order, medial [j]), and so, as Vihman and Croft (2007: 714) assert, "…templates determine the phonological categories of a language". This assertion can be put so strongly because there is ample evidence for templates as the first units of phonological representation. Moreover, there is evidence that phonological categories are built bottom-up from the phonetic information children detect in the speech signal (Pierrehumbert, 2003). If this phonetic information comes from templates that develop out of early motor patterns, then templates can be said to determine the phonological categories of a language.[2]

3.5.2 Relationships among child forms

Traditionally, phonological acquisition research has focused on the relationship between child and adult target forms, with the aim of writing rules to get from the adult to the child form (Smith, 1973). Many child forms, as seen in many of the examples above cannot be adequately analyzed in this way. As Vihman and Croft (2007), among others, have shown, the relationships within an individual's developing phonological repertoire are informative, often revealing idiosyncratic patterns with which a child is working in the early stages of a limited phonological system. For example, Szreder provides data that show what at first appears to be a highly unsystematic approach to the production of initial and medial clusters in a child acquiring Polish. The child Grzenio's utterances were not predictable based on the adult target word. Instead of the particular sounds in

[2] Vihman and Croft (2007) argue that templates function in adult phonology, too, although the present research attends only to developing child phonology.

the target words, the child's attempts seemed to depend more on the position of the cluster within a word. For example, the child replaced the initial clusters in both *elephant* /swɔɲ/ and *bee* /pʃtʃuwka/ with a nasal palatal, which cannot be explained by simple substitution (Szreder 2013: 348). The pattern that surfaces, rather, is the nasal palatal used in place of initial clusters. In fact, Szreder (2013: 348) notes, coronal and dorsal segments were commonly used to replace initial clusters: 50% of initial clusters were reduced to or replaced with coronal consonants and 44% with dorsal consonants, while 6% were reduced to or replaced with labial consonants even though 30% of target clusters contained a labial consonant.

Data from Priestly (1977/2013) additionally exemplifies this concept. Let us return to the example of *hanger* [hæŋə] produced as [hajaŋ] (Priestly, 1977/2013: 220). It is difficult, and perhaps impossible, to account for the child's utterance by way of segment-based rules with the aim of traveling from the adult to the child form. To do so, there must be a rule to omit the final vowel and insert [ja] medially (among other possibilities), and this process would need to apply to all similarly structured words. Accounting for this form by way of rules would be complicated and also inaccurate in the context of the child's entire lexicon. To draw analysis, rather, from relationships among the child's forms is both simpler and more advantageous for describing systematic processes in the child's phonology. The [j]-medial pattern is dominant in the child's lexicon at the time, and Priestly identified a host of "equations" determining the way in which the template was used. Nevertheless, Priestly points out that in addition to the whole-word pattern he observed, simple substitution processes were also in use and may possibly have been the source for the development of the [j]-medial template. Macken

(1979) and Oliveira-Guimarães (2013) also observe substitution processes operating on individual segments concurrent with template use as a child's phonological skills become more advanced.

Once a child has produced 50-100 words, at first based on item-learning, templates typically emerge as a first construction of a phonological system (Vihman, 2002). During a period of increased template use, a child's forms come to sound similar to each other as a result of developing relationships among an individual child's forms. It is quite common, as already noted, for a child to develop homonymous forms for phonetically dissimilar adult targets (Ingram, 1975; Lleó, 1990; Priestly, 1980; Tervoort, 1969; Waterson, 1971). Earlier in this chapter, data from the child P in Waterson (1971) showing similar forms representing the Nasal Structure were presented. Waterson (1971) additionally provides an interesting and detailed account of child forms and corresponding adult targets grouped in the Continuant Structure. These forms are provided in Table 3.1:

Table 3.1 P's forms demonstrating the Continuant Structure.

Child form	Adult target word	Adult target form
[ahʷɔ/æhɔ/aɦ̃ʷʊ̃]	*angel*	[eĩnʤəʷɫ]
[ahʷɔ/æhɔ/aɦ̃ʷʊ̃]	*hymn*	[hɪm]
[ahʷu]	*honey*	[hʌnɪ]
[ẽɦ̃ẽ/hẽɦ̃ẽ]	*Rooney*	[rʷũ:nĩ]

(Data from Waterson, 1971: 190-191)

While the adult target phonetic forms do not resemble each other very closely, the child forms do. Waterson (1971) notes that the homonymous forms for *angel* and *hymn* are likely due to their not being semantically differentiated for the child, who had a hymn-book with angels on the cover. In terms of similarity of structure across the forms in (5), Waterson (1971: 191) notes the disyllabicity of both the child and adult forms and draws attention to the child's use of nasality over the entire form in connection with the strength of nasality in the adult forms. For example, the entire adult phonetic form for *Rooney* bears nasality, and so do both of the child forms. In contrast, only the nasal segment in *honey* has nasality, and in the child form only [h], which Waterson describes as a medial glottal continuant, has nasality. While the correspondence between child and adult forms are unusual and somewhat unpredictable, they can be explained by templatic analysis in view of the child's idiosyncratically developing system.

Variant utterances for a given word can also be problematic for traditional analyses but can often be easily explained by looking to relationships among a child's forms at a given period of time. For example, the child T, studied in Ferguson and Farwell, 1975/2013: 116-117) produced the following variants for *shoe*: [gutɛɪ, guʧɪdi] in one session (Session III), in a later session (Session IV) produced [ɛɔɪ^{ɛ}, t^{h}ɪɛ^{I}u, ɛɪ, ʃɪ], and in a later session yet (Session VI) produced [^{I}ʃu, ʃ^{I}u, ʃu, t^{h}u^{h}]. At different points in the acquisition process, the child is observed to experiment with different sounds and word-shapes to target the same word. By Session VI, T seems to have a better idea of the target-appropriate sounds that compose the word *shoe*. Perhaps the child struggled with sibilant onsets (or sibilants in general) in Session IV; during this session, *see* is also produced with no onset: [ɛːɪ, ɛiː] (Ferguson & Farwell, 1975/2013: 117). These variants can be considered necessary steps in a sort of problem-solving process toward successfully articulating *shoe* as the child gains phonological knowledge. Vihman, DePaolis, and Keren-Portnoy (2009: 173) suggest that variation results from a child having a holistic auditory match by way of momentary memory, in conjunction with production patterns active in the child's current repertoire. It must be remembered that a child does not approach word production like an adult who has knowledge of richly detailed phonetic information about a given word and about the language within which it is situated; rather, as evidence from research on babbling—and on the transition from babbling to first words—shows, the child initiates speech from a place of limited motor, perceptual, and production abilities. While traditional theories of phonological acquisition tend to dismiss variation as noise in the system, dynamic systems theory looks to variation as crucial to understanding developmental processes in play as a system self-organizes (Gershkoff-Stowe, 2004; Thelen & Smith, 1994). A child builds upon what may seem to be mis-steps on the path to a more adult-like phonological system.

3.5.3 Relationships between child and adult forms

The relationship between child forms and their adult targets is important because it points to patterns across words where child forms diverge from adult targets and can illustrate correspondence patterns among a group of words and their adult targets. Waterson (1971) describes five "structures" in the child P's data and offers a detailed analysis of the relationship of words adhering to a given structure and also what features the words using a particular structure share with their adult target forms. For example, the Nasal Structure described earlier in this chapter is defined by a set of basic features including nasality, voiced onset syllable onset, and prominence of the first syllable (1971: 187). These features, among others, tie together the child's words that make use of this structure in the production of first words and differentiate them from words belonging to other structures. In addition to commonalities among words built on the Nasal Structure, Waterson (1971) also observed commonalities among the features in the adult words targeted. These features include continuance, nasality, voiced onset of the second syllable, voiced ending of all syllables, and prominence of the penultimate syllable (Waterson, 1971: 195-196). Some words targeted include *finger* [fiŋgə], *window* [wĩndʷəʷu], *Randall* [rʷændʷɫ], and *another* [ənʌðə] (Waterson, 1971: 195), each of which includes these features. Waterson notes that the syllables that have prominence are enhanced with length in the child forms: [ɲẽ:ɲẽ/ɲiɲɪ] for *finger* and [ɲẽ:ɲẽ] for *window*, for example. Again, Waterson argues that the child produces the features of the adult form that is perceived the most clearly, owing to features with which the child is already familiar. In addition to bringing clarity to the relationship among a given child's words, templatic analysis can also bring insight into the relationship between the child and adult target forms and the choice of a particular template to target a particular word.

While Waterson (1971) described patterns between child and adult target forms, endeavoring to construct a theory of child language acquisition solely by examining segment-by-segment correspondence between child and adult forms is usually inadequate and can obscure patterns in a child's independently developing system. For example, children have been observed to mix up features within a word (Macken, 1979; Khattab & Al-Tamimi, 2013). Khattab & Al-Tamimi (2013: 404) observed the quality of lengthening to appear on variable segments within a word: a CV:CV(C) target may be realized in the form of the established CVC:V(C) pattern, as in [babbah] for /ba:ba/ *daddy*. This behavior is indicative of a child targeting a whole word—or a gestalt (Waterson, 1971)—with the limited phonological tools available in early word production, which results in unusual segmental correspondences in early child data. Waterson (1971)'s data illustrating the Continuant structure, described above, also offer a good example of child data sets requiring an examination of relationships among child forms, as do any of the many examples of consonant harmony throughout the phonological acquisition literature.

3.6 Templates as a bridge to adult-like phonology

Templates are not the sole production strategy in a developing phonological system. For example, segment-oriented substitution processes observed in early production data suggest concurrent attention to individual sounds (Macken, 1979; Oliveira-Guimarães, 2013; Priestly, 1977/2013). Templates are prevalent in early child data, but children develop templates of different content, rely on templates of different quantity, and use templates in different proportions relative to their total utterances. These phenomena serve to highlight the importance of investigating the role of templates in early phonological development, and ascertaining why children use templates in the first place is crucial to understanding template function.

Template use is inversely related to changes in production accuracy (Khattab & Al-Tamimi, 2013; Vihman & Vihman, 2011). Often a u-shaped pattern is seen, wherein a child's first utterances are produced relatively accurately, followed by a period of inaccuracy before target pronunciation improves (Ferguson & Farwell, 1975/2013; Vihman & Velleman, 1989). In their acquisition study of geminate structure in Lebanese Arabic, Khattab and Al-Tamimi (2013) suggest that accurate forms preceding and following a period of increased template use, when accuracy tends to decrease, are qualitatively different: preceding the decrease in accuracy, they propose that children engage in item-based learning, producing utterances word by word without systematic, generalizable phonological knowledge. Accurate forms following the decrease reflect a reorganization of the phonological system, often revealing segmental knowledge (Macken, 1979). During the templatic period, the child sacrifices accuracy in relation to targets while, little by little, acquiring abstract knowledge of the sounds of the language.

Templates have been described as responses to challenges in producing the phonetic details of adult words, be it particular sounds in general, sound sequences, or a sound in a particular syllable position (Vihman & Croft, 2007). Vihman (1978) suggested that children use consonant harmony to reduce the complexity of a target word, allowing the child to focus only on the sounds with which he or she is familiar. Drawing attention to the prevalence and articulatory complexity of Polish clusters, Szreder (2013) suggested that pre-prepared templates assisted the child she studied in producing challenging words, in particular those containing consonant clusters, and that this process was triggered by the overall shape of the word, specifically noting that word-medial clusters affected the stability of initial consonants. She further suggested that the use of a template could be attributed to confusion between similar gestures (between the input and templatic representation), problems in planning and coordinating gestures, and an emerging but limited phonological system built on the child's own production patterns generalized to words that differ in segmental composition (Szreder, 2013: 359).

Concerning the [CVjVC] template he observed, Priestly (1977/2013: 229) proposed that Christopher "internalized" the initial consonant and the first vowel, one other salient consonant (either the second or final consonant), and the disyllabicity of input words. The child's forms, then, "represent realizations of these parts, which were formed into a phonological whole according to one of a number of component substrategies" (Priestly, 1977/2013: 229). These substrategies include the series of equations that Priestly discerned, which account for the patterns that Christopher selected to produce given sets of words. Again, here the child can be said to use a whole-word pattern to reduce the complexity of the words he targets for production. Priestly (1977/2013: 224) suggests that familiarity with certain sounds in the input and ease of articulation are reasons prompting template formation and use. He also points to the substitution of liquids with the preferred [j] as a source of template use, proposing that the [j]-medial template grew out of this substitution process. Similarly, Szreder (2013) also proposes articulatory factors as the source of template formation, because at times a cluster was substituted with a sound agreeing in place of articulation. She notes, however, that template use developed as a means for handling the challenge of producing clusters based only on their "clusterness", regardless of articulatory factors. These details are indicative of templates being the organizational unit of the phonological systems of these children at these particular points in time; these studies also suggest a process, wherein templates develop out of articulatory activity into abstract phonological units.

Templates, again, are fleeting and flexible, evolving in concert with the child's experience with language and increasing phonological knowledge. Waterson (1971) describes the way P's Labial Structure was expanded to target the production of a wider range of words by the incorporation of additional features. Macken (1979) describes another way templates were used to increase lexicon size: new templates were created by way of merging earlier templates. Specifically, the patterns [m_n_] and [p/b_t/d] combined to elicit words using the patterns [p/b_n_] and [p/b_nt_] (Macken, 1979: 24). The phenomenon of template merging is studied in the present research by applying schema theory to templatic analysis. Ultimately, templates become richer in detail as guided by the ambient language and the child's experience with its patterns. Templates begin as simple categories with roots in early vocal motor patterns. If templates indeed determine the phonological categories of a language (Vihman & Croft, 2007: 714), and if phonological categories are built bottom-up (Pierrehumbert, 2003), then we can expect that, as the child's ability to attend to finer phonetic detail becomes more sophisticated and the phonological system becomes fine-tuned for greater complexity, templates become more complex.

Early constraints on neuromotor and perceptual abilities, in coordination with lexical development and ambient-language influence, contribute to the initial construction of phonological system out of early vocal motor patterns (Vihman & Boysson-Bardies, 1994). The ambient language continues to shape the system, and this is reflected in the shape of templates seen in different languages (e.g., Lebanese Arabic: Khattab & Al-Tamimi, 2013; Brazilian Portuguese: Oliveira-Guimarães; 2013; Finnish: Savinainen-Makkonen, 2007; Polish: Szreder, 2013; Finnish: Vihman & Velleman, 2000; French: Wauquier & Yamaguchi, 2013). These studies illustrate that templates are not universal but rather manifest differently, specific to the ambient language or languages. Indeed, schematic analysis in Chapter 8 leads to the possible conclusion that a schematic foot, in accordance with English prosody, constrains the production of words to be comprised of no more than two syllables and at least one syllable. Another example comes from a study targeting quantity in segment production. Vihman and Velleman (2000) analyzed data from French-, English-, and Finnish-acquiring children at the 4-word, 25-word, and 50-word points in order to gauge ambient-language effects, with focus on Finnish geminates. By the 25-word point, Finnish-acquiring children could be distinguished from the other children whose ambient language did not have quantity contrast.

Khattab and Al-Tamimi (2013) observed language-specific similarities and individual differences between three children acquiring Lebanese Arabic, who had differing exposure to English and French. Due to the salience of the medial geminate in Arabic, the authors noted that all children in the study produced words using a disyllabic shape with a medial geminate, sometimes replacing target geminates with clusters or affricates to maintain heaviness in the medial position. The children also adapted words to a CVC:V(C) shape. In contrast with children in a study of Finnish, which also has medial geminates, the Arabic-acquiring children more stably produced word-initial consonants, concordant with the importance of initial consonants in Arabic phonology. A difference between the children is seen in the proportion of disyllabic and monosyllabic forms, which correlated with differences in exposure to English. Specifically, the child Rama, who had much exposure to English, used a greater proportion of monosyllabic forms than the child Martin, who had almost no exposure to English. By the final session of the study, 40% of Rama's utterances were monosyllabic, while by the final session, 71% of Martin's total utterances used the CVC:V(C) shape (Khattab & Al-Tamimi, 2013: 394-398). While similarity was found in the production among children acquiring Lebanese Arabic, variation was found in their individual paths.

Individual differences are seen in the earliest utterances across children, which develop out of prelinguistic vocal patterns in response to the ambient language and their own emerging vocal control (Vihman, Velleman, & McCune, 1994). These are phenomena that can be accounted for by conceptualizing representation as highly interactive processes in an emerging dynamic system (see Chapter 4). Again, individual differences dissipate across children as phonological knowledge is gained and child forms more closely match adult targets (Vihman & Boysson-Bardies, 1994). These findings highlight the child-specific nature of phonological systems during the templatic period, offering support for emergent theories of acquisition. Some children rely heavily on one or two patterns (Priestly, 1977/2013; Vihman & Vihman, 2011), while others make use of multiple templates (Macken, 1979; Waterson, 1971) of varying proportionality. Some children use different templates—or different strategies altogether—to target the same word, which results in quite different variants of the same word. A given child may produce several variants for one word and a stable utterance for another word (Ferguson & Farwell, 1975/2013). Templatic analysis can address this range of phenomena, and is particularly suited to do so interpreted within dynamic systems theory (Smith & Thelen, 1994), which is the focus of the following chapter. In the early period of word production, when a child has limited phonological knowledge and immature control over the vocal apparatus, templates as schematic whole-word patterns offer the child a means to increase the lexicon size and enhance the ability to communicate while working out the phonetic details of the ambient language. By this process, templates contribute to the construction of a first phonological system.

Chapter 4: Overview of dynamic systems theory

> *"The challenge of a dynamical formulation is to understand how the system can generate its own change, through its own activity, and within its own continuing dynamics, be it the springlike attractors of the limbs or the neural dynamics of the brain."*
>
> *(Thelen, 1995: 91)*

4.1 Introduction

The major task set upon emergentist theories of language is how to model the way in which a human being can acquire a system as complex as language without an innate representational capacity specified for it. A discussion of emergentist theories in contrast with nativist theories appears in Chapter 1, where dynamic systems theory (DST) is introduced as an emergentist theory of language development. In emergentist theories of language, general cognitive capacities drive the organization of linguistic structures in a system, which arises from the interaction between units of processing. DST is valuable in its ability to conceptualize and explain complex interrelationships between time, process, and the elements of a system and, furthermore, for its utility in numerous domains of study. The challenge described in the epigraph points to the central properties of DST—self-organization, continuous time, and embodiment—which together respond to the task at hand. These properties enable DST to capture the most challenging features of an incipient language system, including interacting variables, non-linearity, and some degree of unpredictability. The main properties of DST are addressed in detail below, first, in order to describe the tenets of the theory, and, second, in order to make clear how DST is used in this research as a suitable and advantageous framework in which to interpret the processes involved with phonological acquisition.

Dynamic systems, comprised of numerical states found in many mathematical and scientific contexts, are at the center of DST (van Gelder & Port, 1995). While DST originates in mathematics, its principles can be understood and employed without intimate dependence on the equations involved. Dynamic systems are characterized by interconnectedness, by which every system and sub-system are interrelated, so that a change in one system affects change in the others (Gershkoff-Stowe & Thelen, 2004; McCune, 1992; Thelen & Smith, 1994). DST can account for the processes of cognition with not only theoretical—but also biological—plausibility. This theory enables a description of cognition such that cognition is conceived not only as states of the brain but of a whole organism, including the nervous system, the body, and the environment with which the organism interacts (van Gelder & Port, 1995), and in particular the processes involved with the development of an organism (Thelen & Smith, 1994). This is what is meant by time-dependent states, introduced in Chapter 1, as a suitable way to talk about what is typically referred to as representation within linguistics scholarship.

The research undertaken here examines developing phonological systems conceptualized as real dynamic systems (i.e., "a concrete object which changes over time"), rather than as mathematical dynamic systems (Giunti, 1995: 550), with an understanding that articulatory gestures are not independent of the developing cognitive system (Browman & Goldstein, 1995). The central principles of dynamic systems, in particular self-organization, embodiment, and continuity in real time receive focus in the context of phonological development. Attractors, phase shifts, and soft assembly are are turned to as features of dynamic systems to describe developmental processes, in particular the behavior of phonological templates (see Chapter 3). These features are described and discussed below in the context of the templatic framework.

4.2 Self-organization

The spontaneous emergence of order is characteristic of biological systems, as is the subsequent dissolution followed by re-organization. As a dynamic system, the component parts of an organism may spontaneously form patterns of new behavior (Kelso, 1997), and may do so as a way to solve a problem (Thelen & Smith, 1994). Thelen and Smith (2003) offer the example of a baby crawling as a means of locomotion that befits the baby's current capacity, noting that the baby is not hard-wired to crawl. Instead a baby with the strength and coordination to crawl does so in order to get from one place to another, until a more efficient solution is reached—like walking. A child will walk when he or she has achieved sufficient strength and capacity for upright posture and balance. Crawling can be viewed as a temporarily stable, self-organizing behavior that will gradually be subsumed by walking, at which time crawling behavior destabilizes.

The principle of self-organization is a defining characteristic of DST. By "organization" is meant parts put together as a whole in some ordered way. Ashby (1962: 266) describes "self-organization" as a system that changes from "parts separated" to "parts joined" and the behavior of each part is affected by that of the other parts. In this sense, the notion of time is essential in the interpretation of development as a dynamic system. Each of the parts of an organized whole continuously interacts with the others, affecting the overall organization in any number of ways at any given point in time, as a result of the configuration of parts in the previous point in time. Out of the relatively unpredictable dynamism between subsystems and changing relations between an organism's own activity and the task environment, new behaviors emerge (Smith & Thelen, 2003: 343; Thelen, 1991: 344).

The property of self-organization enables DST to accurately capture language use and development without having to rely on assumed innate structures. Lewis (2000: 38-39) describes four features of the processes of self-organization: A self-organizing system (1) allows for the emergence of novel behavior, (2) becomes increasingly complex in the course of development, (3) undergoes global reorganization in periods of instability, and is simultaneously sensitive to changing variables and stable by nature. That is, a dynamic system contains properties that both allow easily for novelty of form and offer some constraint on what would otherwise be wild, structureless entities. Nativist linguistic theories have difficulty accounting for novelty in language, but a developing linguistic system is rife with novelty. In terms of phonology, a child initially approaches the production of words with a limited repertoire of sounds, resulting in unexpected and unpredictable word-shapes. As the child continues to be exposed to language, he or she will acquire increasingly complex knowledge of the sound system of that language. There will be points of instability during which the child seems to regress before improving further (Becker & Tessier, 2011; Bowerman, 1982; Byun et al., 2016; Khattab & Al-Tamimi, 2013), and points at which the child's more accurate production abilities suggest that the system has undergone reorganization (Macken, 1979; Vihman & Velleman, 1989). For example, following periods of reliance by many children on idiosyncratic word-shaped patterns to facilitate production, children will begin to produce words whose deviation from target forms can be described by segment-based rules (Macken, 1979;

Oliveira-Guimarães, 2013; Vihman & Vihman, 2011). This suggests a shift in representation from whole-word units to the primary organization of a phonological system around the segment. More aptly, in terms of DST, this suggests a shift in the stability of the current configuration of behavioral processes. The property of self-organization allows a child's trajectory to trace sometimes idiosyncratic curves while still staying on course toward adult-like language.

Smith and Thelen (2003) point to the ideas of multicausality and nested time-scales as two major principles of DST that contribute to the self-organization of a system. Regarding the former, a dynamic system exhibits coherent behavior without an agent or program that designs a predetermined organized pattern. Rather, each of a system's component parts contribute to a given task or behavior, and no single component has priority over another. A study discussed in McCune (1992, conducted with Marilyn Vihman and Charles Ferguson), examined variables involved in the emergence of first words, with the purpose of identifying the developmental sources of language. The researchers studied 10 infants, measuring the timing of the emergence of the following variables: first words, mental representation (by way of object permanence and pretend play), vocal motor schemes, and communicative grunts. While some broad generalizations could be made, it was concluded that only limited predictive power is possible by looking at any given variable and only in individual cases. For example, a limited set of sounds and less stable use of vocal motor schemes in the group of infants who had been categorized as late-talkers seemed to be indicative of sensorimotor limitations. By identifying the variables that contribute to a task like word production, we can assess the timing of each one in relationship to the others and then compare data sets across children. Each child's system organizes itself by way of its individualized parts, and no single part is necessarily the driving force. That is, each child's path differs to some degree and at different points in the overarching developmental process. Individual variability and noisy data, as a consequence, are expected.

Among the domains that contribute to the transition of a pre-linguistic child to language use are the cognitive, motor, biological, and psychosocial domains (see McCune, 1992; McCune, 2013; Thelen, 1991; Thelen & Smith, 1994). It is suggested in McCune (1992) that any one of these subsystems can function as a control parameter within the whole system, such that reaching a new phase may require a given subsystem to reach critical value. That is, a given parameter's course in continuous time leads to a substantive change in the system's overall landscape. A "control parameter", however, should not be thought of as a component with sole power over a system's configuration. Rather the system is sensitive to each of its parameters, and a parameter that sufficiently changes affects the whole system, leading it into different states (Thelen & Smith, 2006). McCune (1992) offers the example of a child having undergone tracheostomy, who subsequently experiences structural difficulty. The child may exhibit speech delays until the vocal capacity catches up, even if the child has developed a capacity for representational play sufficient for language use. Prelinguistic behavior remains stable in a system until at least one of the contributing variables, like vocal capacity, reaches critical value, causing a pattern shift characterizing a more advanced linguistic phase. This property of multicausality challenges our ability to pinpoint the timing involved with any single developmental source of language, at least with any degree of predictability beyond the individual. This is a result of the system being self-organizing by nature and, thus, subject to the effects of change in any of the system's subcomponents.

Nested time-scales also play a role in self-organization. This characteristic can be thought of in relationship to the study reported in McCune (1992). Each variable studied has its own time-scale: first words, mental representation, vocal motor schemes, communicative grunts; and each variable with its own time-scale can communicate with the other variables because it is continuous with the others. For example, for one child first words emerged at 9 months, pretend play at 9 months, and object permanence at 10 months. For another child, first words emerged at 11 months, pretend play at 10 months, and object permanence at 9 months. Each of these two children developed along relatively similar trajectories, but for each of these children the emergence of first words, pretend play, and object permanence developed along different, individualized time-scales. At the same time, the time-scale for each factor—in each child—functions in interaction with that of the other factors in the course of development. Idiosyncratic developmental trajectories at the local level, then, integrate to form a coherent whole at the global level, advancing the overall developmental course dynamically affected by its subcomponents.

If development is thought of as a dynamic system, one that by nature self-organizes, its elements can be seen to come together in patterns of behavior, some of which are stronger and more resilient than others, as a result of the child's prior developmental trajectory. With this, it is not necessary to posit innately wired designs that a child will inevitably trace from stage to stage. Thelen (1991) suggests that processes of somatic growth and the intimate interaction between the organism and its environment spur development. In fact, what may be perceived as stages are actually only periods of stable behavior followed by the dissolution of stability. Smith and Thelen (2003: 344) describe development "as a series of evolving and dissolving patterns of varying dynamic stability, rather than an inevitable march towards maturity". Instead of marching rigidly in line toward a well-defined goal, a system organizes itself by way of its own activity, undergoing changes that stabilize and destabilize what is at its core. This behavior can be described by pointing to attractors, phase shifts, and soft assembly.

4.2.1 Attractors

Development is composed of what can be described as preferred behavioral states that vary in degree of stability (Thelen, 1995). In the course of development, systems and sub-systems settle into states that can become so stable they take on the appearance of static entities, or of stages. This is why we see, in an otherwise continuously developing system, apparent discontinuities between one supposed stage and another. These states of stability within a dynamic system are attractors. As preferred patterns of behavior, attractor states can enable reasonable estimations of current systematicity. Contrasting "so-called repeller states", de Bot and colleagues (2007: 8) provide a useful analogy to show how patterns of behavior settle into some states and move away from others. Imagine a ball rolling over a surface covered in holes and bumps. The ball will settle into the holes (attractor states), however temporarily, and bounce off of or roll over or away from the bumps (repeller states). The deeper the hole the ball falls into, the stronger the effect of attraction is. The analogy is offered in an exposition of the tenets of DST, which introduces an argument supporting the use of DST in second language acquisition research and, more generally, for a theory of language development on the whole.

Indeed while some attractor states may have the appearance of stability dependent on the strength of attraction, they are only temporary states (de Bot et al., 2007; Thelen & Smith, 1994). An attractor state can become unstable and when that happens, its system looks for “new coordinative modes” in response to a given task (Thelen, 1995: 91). Thelen (1991: 342) describes an attractor as a “preferred configuration within a particular set of boundary conditions” that “acts as a magnet, drawing the system into that state from many initial positions and even when perturbed”. An important idea here, beyond that of attractive force, is that of initial positions (or conditions) and, furthermore, that there are many. Each of the variable component parts of an attractor emerges with a certain set of properties from a certain environment and undergoes a certain trajectory to find itself within a given configuration among other component parts. Drawn together by kindred properties, the cluster of parts is held together by temporary boundary conditions determined by the organism itself, the environment with which the organism interacts, and the task at hand (Thelen, 1991: 342). Since each of these variables is subject to change, so are the boundary conditions.

From the perspective of phonological acquisition, Menn and Matthei (1992) suggested that templates serve as attractors for output forms, building on the idea that attractive force enables the processes of entrenchment and generalization from one form to another. The idiosyncratic use of word-shaped patterns is commonly found in early child production (Macken, 1979; Menn, 1971; Priestly, 1977; Vihman & Croft, 2007; Waterson, 1971). At first these patterns are used to select words for production whose target pronunciations contain these patterns, and then the pattern will be generalized and extended to facilitate the production of words whose target phonetic contents do not match (Vihman, 2016). This is typically when the child has acquired approximately10-50 words.

Szreder (2013) presents an interesting account of a monolingual Polish-acquiring child, examining the child's production of clusters in Polish. Consonant clusters are predominant in Polish phonology, with a greater variation of clusters occurring in word-medial position than word-initial or word-final. Grzenio, the child whose data Szreder examines, produces either coronal or dorsal segments in place of word-initial clusters and one of three patterns in place of word-medial clusters: p + obstruent, homorganic nasal + obstruent, and continuant + noncontinuant. These patterns are not predictable based on the phonetic content of the target word. Rather the child's use of a given pattern seems depend on the position of the word in which a target cluster appears and often agrees in place of articulation. Szreder (2013) argues that this behavior suggests, at least in part, that articulatory factors are responsible for the generation and establishment of templates in the child's speech. Noting that the substitution of clusters with the patterns described above can later be described to occur in any word having a cluster, Szreder (2013) suggests that articulatory difficulties may be more accurately described as the source of child errors, from which productive templates emerged and came to be applied to any cluster-bearing word.

In this way, Grzenio's templates described above emerged as attractors, or "preferred configurations" (Thelen, 1991: 342), in the production of words containing consonant clusters. Furthermore, it was the child's individual linguistic experience that contributed to the development of particular templates from many initial positions. In terms of producing consonant clusters, we can see the products of Grzenio's developing phonological system organizing itself by way of its current set of conditions: the sounds in Grzenio's phonological repertoire, the phonetic content of words he targeted, and the solutions he developed and established (i.e., templates) to produce challenging sequences using the tools available to him.

4.2.2 Phase shifts

When the values of the internal or external conditions of a given system reach a critical point in response to changes within any of the relevant variables, the system undergoes spontaneous reorganization (McCune, 2013; Thelen, 1991). In a phase shift, the elements in a system's given configuration loosen and may reassemble in response to changing boundary conditions determined by the organism, the organism's environment, and the task (Thelen, 1991: 342). When the cohesiveness of a system's subunits is disrupted, the system seeks a new attractor, or a new means of stability. Phase shifts offer a way to conceptualize apparent discontinuity in a developing system. For example, returning to the example of a child's locomotive capacity, one day a baby is crawling, unable to walk, and then one day a child walks. Similarly, McCune (1992) describes the transition from preverbal to verbal language as a phase shift. That is, one day a child is babbling, producing sounds with no associated meaning, and then one day makes an apparent leap to intentionally produce utterances linked with meaning. Phase shifts within a dynamic system allow us to see processes at the local level, in a system's subunits, which contribute to the slow, gradual change leading to new behaviors like walking or producing speech.

At least two major phase shifts are clearly identifiable in phonological development. McCune (2013) has written about the importance of the focus on the period from babbling just into first words that much templatic research targets. This research highlights the use of idiosyncratic motor patterns in babbling that tend to be found in early templates. These patterns give us a window into the phase shift between babbling and intentional language. Another clear place where we see phase shift in phonological development is in the transition of a child's system from being organized around whole-word patterns to being organized around segments (Macken, 1979; Oliveira-Guimarães; 2013; Vihman & Vihman, 2011).

Macken (1979)'s diary study of Si, acquiring Mexican Spanish, provides an example of a phase shift between templatic and segmental knowledge. When Si began producing words, she exhibited a "front + back" pattern, in which a consonant produced further forward in the articulatory space preceded one produced further back in an utterance containing more than one consonant (Macken, 1979: 21). Early patterns included [p/b_t/d_] and [m_n_], where an underscore indicates a slot for a vowel, and later a "velar stop + dental stop" pattern emerged, together suggesting the preference for a medial dental in a whole-word context. While in the course of development additional whole-word patterns developed, Macken sites evidence of simultaneously developing phonemic contrast. Si's velar and dental stops at first were merged, but at age 1;8.7, Si inconsistently produced contrast, and then at age 1;9 contrast between these places of articulation was established.

Macken's (1979) close attention to Si's production behavior allows us to see a gradual change in the developing phonological system as its primary unit of organization shifted from whole-word patterns to segments. Evidence of the acquisition of segmental knowledge is concurrent with the dominant use of whole-word patterns in production. From age 1;7 to 2;1, preferred word patterns dominated the order in which consonants occurred in Si's production. Then during the period of age 2;2–2;5 consonant order became more target-appropriate and unusual substitutions resulting from the use of whole-word patterns disappeared. By this time, Si had acquired most of the consonantal phonemes of Spanish. This case study illustrates a shift from a template-centered to a segment-centered phase in phonological development and overlap between the two phases. The shift was gradual as the boundary conditions holding together a template-based phonology became unstable as a result of Si acquiring greater, more nuanced phonological knowledge of the ambient language.

4.2.3 Soft assembly

The property of soft assembly enables a system's elements to readily reconfigure. Within a dynamic system, behavior is organized by the temporary configuration of variables held together by fluctuating degrees of attraction (Gershkoff-Stowe & Thelen, 2004). Importantly, no single configuration is derivable from a group of variables assembled toward a given task (McCune, 1992; Smith & Thelen, 2003). Many systems are in play and, at any given point, some variables could have greater strength than others in a behavioral configuration, as a result of factors both internal and external to the organism and of the preceding attractive configuration available. As described above, attractor states underlie the stability of an assembled configuration of units, and phase shifts describe the destabilization of a behavioral configuration when boundary conditions change. Configurations are temporary, subject to continuous change, because their subunits are only softly assembled and not held together by any “a priori formula” designed guide a set developmental process (Thelen, 1991: 344).

Considering attractors, phase shifts, and the property of soft assembly together allows us to conceptualize both the formation and evolution of a template. A template serves as an attractor in a developing phonological system, until boundary conditions change and the system undergoes a phase shift (e.g., from babbling to first words, from templatic to segmental organization, from organization around one template to another). This is possible because the elements in a configuration are only softly assembled and not hard-wired innate units. We are also able to see how templates might merge as a system becomes more complex. For example, Macken (1979: 21) reports that her subject expanded the number of patterns she used for production by combining previously established patterns. Two early patterns consistently used both accurately and inaccurately in Si’s production were [m_n_] and [p/b_t/d_], which in a later stage of development combined to result in [p/b_n_] and [p/b_nt_]. Data reported in Chapters 7 and 8 similarly illustrate merging patterns in the child Djuna’s developing system as it becomes more complex. Loose attractor states, or semi-established patterns, in a child’s repertoire are capable of merging with others because the elements of the system are only softly assembled and, thus, subject to reorganization in response to changes to the system on the whole, and this happens in real-time processing in the course of development.

4.3 Time

The element of time is not factored into traditional phonological theory. Port and Leary (2005), however, present a detailed argument laying out criticism of a formalist approach to phonology in favor of one that incorporates the notion of time into language processing. Facts from phonetics offering support for the argument suggest that a formalist view of phonology proffering static symbolic representation could not be correct. For example, if we accept the parameters of a phonological system as laid out in Chomsky and Halle (1968), which provides the groundwork for formalist and nativist theories of phonology, then we must accept a closed system of sound that can be described by a closed set of features (i.e., hard-assembly). This leads us to an orderly system that theoretically houses a description of the set of sounds found in every language. However, the set of sounds found across language is not closed (Ladefoged & Maddieson, 1996; Port & Leary, 2005). In fact, the International Phonetic Alphabet (IPA) periodically updates its set of symbols designed to represent the sounds of the world's languages to reflect the addition of sounds not previously represented. That human speech necessitates update should not come as a surprise. The articulatory space is continuous and not cleanly compartmentalized, so we should expect to see the sounds of a language shift in the articulatory space, requiring new symbols for representation in transcription. The need for lexical contrast puts additional pressure on the continued maintenance of this system.

Continuity of the time-scale is critically important in DST (Thelen, 1995). Change in a system across time, which characterizes a dynamic system, can be expressed in the equation $x_{(t+1)=}f(x_{(t)})$: "for any function describing how a state *x* at *t* is transformed into a new state x at time $t + 1$" (de Bot et al., 2007: 8). In words, we can say that a state within a system is constantly in flux in the course of real time from any given point in time to the next, and is built from its previous states. A consequence of this constant state of flux is some degree of unpredictability. While some systematicity can be found and described among variables in a dynamic system, it is impossible for the theory to be thoroughly predictive. This is due to the interconnectedness between both internal and external variables and the possibility for change in any given variable in continuous time, which affects other variables.

Time is not simply a property of language and, thus, language development; it is a property that is necessarily part of the mental categories of sound that we form. For example, noise duration distinguishes sibilant from non-sibilant fricatives (Behrens & Blumstein, 1988), and temporal information is important in the perception of place of articulation (Kewley-Port, 1983; Walley & Carrell, 1983). Port and Leary (2005: 931), in fact, point to time as an "intrinsic property of language". To accurately describe speech sounds, consonants must be described by place and manner of articulation and voicing and vowels by height, backness, tenseness, and roundedness, accompanied by diacritics indicating finer detail. To describe the way a given sound occurs in real-time speech, the effects of speaking rate and measures like vowel and consonant duration and voice onset time (VOT) must also be included. Notably, time has no representation in the symbols of the IPA, but experimental studies show that it warrants representation. Segment duration is an important cue in the perception of speech in various ways, including the discrimination of voicing, segment sequences, the location of a segment in a phrase, and the detection of stress, among others (Klatt, 1976). Port (1981) examined the effect of combined features in VC sequences on timing in English and concluded that abstract timing rules are operative in the language. Flege and Hillebrand (1986) found that while vowel duration contributed to judgments of contrast between /s/ and /z/ in native and non-native English speakers, fricative duration was a reliable cue across only particular groups of non-native speakers studied. These studies show that people are sensitive to temporal cues in speech—to varying and complex degrees dependent on native-language characteristics. This affects the way that perception, and also production, contributes to the formation of mental categories. Evidence of speech timing cues in interaction is especially suited to a dynamic systems treatment capable of handling real-time processing.

We can place these ideas in the context of acquisition. While perception is not the focus of this research, the close integration of perceptual with production capacities of language-acquiring children underlies the templatic framework. The sounds that comprise an adult phonological system are subject to subtle and slow, gradual change, and as such are relatively stable compared to the variation seen in child word production. It is common for children to produce multiple different forms targeting the same word; data presented in Chapter 7 illustrate this phenomenon, including cases where different templates are "tried out" for this purpose. As Smith and Thelen (1994: 134) point out, "…the process of exploration and selection is the major pathway for developmental change. Thus, controlled variability stands as the source of new forms in both real and ontogenetic time." The quality of variation observed in child speech has made crafting a solid theory challenging to both linguists and developmental psychologists. DST not only recognizes what other theories classify as noise in the system; it sees this noise as integral to understanding developmental processes (Gershkoff-Stowe & Thelen, 2004), and does so by following developmental processes in real time.

The templatic approach to early-developing phonological acquisition necessitates a basic understanding that the units of phonology are continuously developing word-based structures that encompass detail beyond the relevant articulatory features, and are not static symbols as traditional theory (e.g., Chomsky & Halle, 1968) would suggest. While templates are referred to as “established” or “routinized”, they are only temporarily so, subject to the effects of real-time speech described above and the subtle phonetic details therein. A child acquires language rapidly, from a place of limited tools and skills to a capacity for great complexity, and templates allow us to observe (1) the transition from the child’s early production repertoire to preferred patterns or attractor states, (2) changes in preferred patterns, or phase shifts, in response to a child’s experience with the language, and (3) either the merging or dissolution of patterns. For example, we can envision that Si’s merged patterns described above (Macken, 1979) are the result of her developing perceptive ability becoming more attuned to the details of segmental duration, VOT, the interaction of timing between segmental sequences, and speech rate, in coordination with her attempts to produce words with her limited production capacity at the time.

In this network of variables whose activity is inseparable from time, we can see the effect of nested time-scales and continuity between them (Smith & Thelen, 2003). We can also begin to see the way in which time-scale continuity is directly related to continuity between the body that coordinates to produce language and the mind that houses the cognitive capacity to do so (Thelen, 1995).

4.4 Embodiment

The idea that mind and body are continuous is essential to DST, highlighting the continuity between the mental and physical systems of an organism and, thus, the relevance of referencing the whole organism in studies of development. Johnson (1987) argues that human thought is centered in the positioning and movement patterns of the body in physical space. Language as a mode of human thought, thus, has its source in the body. Support for the embodiment of conceptual structure can be found across many domains of thought, from concepts like metaphor (Johnson, 1987; Lakoff, 1987) to mathematics (Lakoff & Núñez, 2000; Núñez, 2008). By claiming that cognition is grounded in the body and, in fact, that the very foundations of cognition are born from "the mundane physical events of infancy" (Thelen, 1995: 71), DST addresses the persistent philosophical issue of mind/body dualism. Because the processes of the mind and body are continuous, a dualistic perspective prevents complete understanding of an organism, unnecessarily perpetuating a split between mind and body.

Research that illustrates the coordination of physical and cognitive abilities in development can make this idea more clear. Thelen et al. (1993) report a study of the development of reaching interpreted within DST. The act of reaching for something—a toy, a cup of water, a piece of mail—requires a complex of coordinated movements, requiring the visual capacity to pinpoint the object's location, the coordination of the shoulder, arm, and hand muscles, and the perception and cognition involved with planning the event. While the study investigated reaching on a week-by-week basis in four infants from the age of three weeks through one year, Thelen (1995) highlights two of the infants whose paths notably differed: Gabriel was very active and his first attempts at reaching followed directly from the kinds of movements he had been making with his arms. Hannah, on the other hand, tended to look around more and move less before her first reaching attempt, and her first attempt was characterized by well-coordinated movements from a still position. These differences directly impacted the task required of each child in subsequent steps of development; Gabriel needed to gain control of his wildly active movements, and Hannah needed to put more energy into her movement in order to successfully reach for an object put before each of them.

Both children ultimately attained the goal of reaching for and grabbing an object but did so by following different trajectories. Movements described as non-reaching were documented in addition to those pertaining to reaching in order to examine the way that reaching emerged out of the inherent dynamics of each child's current capacity. Each child was tasked with solving a different set of problems along the way, which one can see clearly when examining the detailed progression of movements by each child toward the first goal-directed reaching. In this way, the study illustrates continuity between body and mind such that coordinated motor abilities developed in connection with problem-solving and planning abilities. This study also illustrates associated continuity in time-scale. Examining the progression of each child reveals his or her current repertoire of movement abilities, and the way that each idiosyncratically unfolded in real time toward the goal.

We may extend this sort of trajectory to that of acquiring language—including phonological, syntactic, and semantic structures, as a child progresses from babbling to templates to more adult-like word production. The production of speech is the result of the coordination of many anatomical and physiological processes geared toward a given task (Thelen, 1991: 342), and the motoric patterns involved with the execution of speech are integrated with the cognitive units associated with language (Langacker, 1987). This will be discussed further in Chapter 5 in the context of schema theory.

The templatic approach argues for an abstract phonological system that begins with the physicality involved with perceiving and producing speech (McCune & Vihman, 1987; Vihman & Croft, 2007). The idea of embodiment, then, is important when we highlight the relationship between phonology as an abstract system and the phonetic detail of speech. Browman and Goldstein (1995) argue that a phonological system and the phonetic detail produced in speech should not be studied independent of one another and, specifically, that the two should be considered to be two levels—macrocosmic and microcosmic, respectively—of the same system. Another way to look at this is in terms of local and global levels of development, wherein the fine phonetic details of speech comprise local levels of development, and an abstract system rises out of the relationships between these details at a global level. This idea is relevant when we conceptualize the acquisition of a phonological system such that a child experiences first the phonetic material of speech and ultimately uses this material to develop phonological categories (Vihman & Velleman, 2000).

That embodiment should be part of a theoretical approach to language seems like an easy conclusion when the focus is put to acquisition processes. Before a child produces meaningful language, he or she produces sounds with little control of the vocal apparatus, ultimately progressing to attain coordinated control of the articulators in connection with the developing cognitive structures. The bodily movements of the child construct a direct path to the establishment of abstract linguistic systems in connection with associated meaning.

4.5 Phonology as a dynamic system

To conclude this chapter, this final section zeroes in on the notion of phonology as a dynamic system, addressing both templates and the important concept of representation. Mohanan (1992: 659) describes phonological development as “pattern formation and adaptation, not knowledge discovery and deduction”. This is in the context of a detailed argument in support of conceptualizing phonology as a dynamic system, in contrast with generative accounts. In this formulation, children acquiring language form phonological patterns by way of coordinating their early production, perception, and motor activities with details of their experience with the ambient language, and not by way of unpacking knowledge from assumed innate bases. Templates found in early child production data are good evidence of this.

Templates are not present at the outset of acquisition but rather emerge as a strategy in word production in response to a child’s trajectory of linguistic experience. Evidence of continuity between babbling and first words, supporting this notion, is abundant (Elbers & Ton, 1985; Stoel-Gammon, 1989; Vihman, Ferguson, & Elbert, 1986; Vihman et al., 2009). Vihman and McCune (1987) found that children tend to produce a limited set of prelinguistic sounds they call vocal motor schemes, which vary from child to child and influence the production of first words. McCune and Vihman (2001) conducted a study of 20 children investigating the timing of the establishment of vocal motor schemes in babbling in relationship to consonants produced among each child's first words. While some consonants were common in vocal motor schemes across many children (e.g., [t/d] and [p/b]), less common consonants were also documented (e.g., [k/g], [s], [m], [n], [l]; McCune & Vihman, 2001: 676), and the consonants in first words were based on those in each child's specific vocal motor scheme repertoire (McCune & Vihman, 2001: 678). DST places emphasis on the role of initial conditions in the subsequent trajectory of development. Viewing language development as a dynamic system allows us to understand the way in which a child's current capacity for speech production is necessarily built on previous configurations of coordinated capacities, including those of motor, cognitive, kinaesthetic, and social domains. In the way that successful reaching emerges out of earlier, less coordinated movements, a child's first words emerge out of earlier, less meaningful vocalizations.

Templatic research illustrates, further, that children in the earliest stages of word production represent an emerging phonological system not with features or segments but with holistic patterns based on words (Ferguson & Farwell, 1975; Macken, 1979; Menn, 1971; Priestly, 1977; Velleman & Vihman, 2002; Vihman & Croft, 2007; Waterson, 1971), and these preferred behaviors exhibit characteristics of the ambient language to which the child is exposed (Khattab & Al-Tamimi, 2013; Oliveira-Guimarães, 2013; Savinainen-Makkonen, 2007; Szreder, 2013; Wauquier & Yamaguchi, 2013). For example, Savinainen-Makkonen (2007) examines the geminate template in the acquisition of Finnish and its affect on the early structures acquired by Finnish children. Khattab & Al-Tamimi (2013) report the use of medial-geminate patterns used by children acquiring Lebanese Arabic, noting the frequency of medial geminates in the input; specific preferences within this pattern varied from child to child and also sometimes within a given child's production. Szreder (2013), additionally, presents data from a Polish-acquiring child in which template use depends on the position target consonant clusters within a word, having described the distribution of consonant cluster types in Polish. Templates as early representational units—reconceptualized here as preferred behavioral configurations—are not innate but rather evolve and participate in a developing phonological system by way of an individual child's preferences, in connection with the phonetic details of the language with which that child interacts. This happens by way of the property of attractive force in a self-organizing dynamic system.

DST eliminates the competence/performance dichotomy found in nativist theories, abandoning the need for rules that lead from underlying representations to phonetic realizations in production. Again, the idea of representation is dispensed with in a DST framework, in favor of a conceptualization characterized by continuously interactive processes subject to the dynamic influence of system-internal components and external forces. "All that is meant by representation in the connectionist and dynamical systems account is that the *theorist* can see correspondences between internal patterns and regularities in the world" (Smith & Samuelson, 2003: 434). To use the term "representation" in DST is to refer to behavior distributed "over many different kinds of *processes*—perception, action, the hardness of the floor, the location of the hiding wells", which is "emergent in the moment, in the task, out of the particulars at hand" (Smith & Samuelson, 2003: 436). When the present research uses the term "representation", it is this notion of multiple, emergent processes continuous in time that is intended. As a "representational unit", a template is a continuously evolving set of processes subject to subtle shifts in the components of the larger phonological system. Again, changes at the local level—a templatic unit or its smaller phonological details—in response to the ambient language, affect any given state of the larger system at the global level.

Research in phonological acquisition requires attention to many developmental factors, and the investigation of templatic behavior, in particular, requires close attention to the details of a child's production history, including forms seemingly aberrant or anomalous. Templatic behavior offers a valuable window into phonological development, which is most advantageously described within a dynamic systems framework as an incipient phonological system fumbles its course through states of varying stability. Differences in template composition that develop out of early babbling patterns in a given child's repertoire and in direct relationship with linguistic structure found in the ambient language offer support for an emergentist rather than nativist approach to acquisition. The concepts found within DST, in particular, effectively advance our ability to capture the early stages of phonological acquisition in detail, including the range of variant and stable production patterns commonly found in early child data.

Chapter 5: An overview of cognitive linguistics

5.1 Introduction

Cognitive linguistics grew out of modern cognitive science in the 1970s as an approach to linguistic analysis (Evans & Green, 2006; Taylor, 2002). Like dynamic systems theory, cognitive linguistics is not a stringently specified theory but rather an approach capable of encapsulating other approaches. As dynamic systems theory can support a connectionist approach to cognition (Smith & Samuelson, 2003), cognitive linguistics offers a platform for a variety of related theoretical approaches to grammar that have grown out of advances in cognitive science (Evans & Green, 2006; Lakoff, 1991). These include cognitive grammar (Langacker, 1987; Taylor, 2002) and a range of perspectives on construction grammar (Bergen & Chang, 2005; Croft, 2001; Goldberg, 1995). Croft's (2001) Radical Construction Grammar serves as a foundation out of which Vihman and Croft's (2007) templatic approach to early phonological development has grown. The present research employs the ideas found in cognitive grammar but does not make a point of argument out of contrasting it with construction grammar.

The main tenets that characterize cognitive linguistics include the generalization commitment, the cognitive commitment, the notion of embodiment, and the symbolic thesis. Additionally, unlike generative grammar, which asserts a distinction between competence—one's knowledge of language, and performance—one's use of language (Chomsky, 1965), cognitive linguistics does not recognize this distinction (Evans & Green, 2006). This is because, from the cognitive perspective—unlike the generativist perspective, the language capacity is not considered at its inception to be modular and independent from other cognitive capacities; rather, linguistic structure is viewed to emerge from language use (Croft & Cruse, 2004; Langacker, 1987; Langacker, 2000). This conception of linguistic structure dissolves the separation between the knowledge and use of language and also simplifies how the mental representation of language is conceived. Below, each of the tenets of cognitive linguistics is elaborated, followed by an overview of phonology and then acquisition within the cognitive linguistics literature. The way in which the idea of degrees of abstraction within schema theory can be compatible with dynamic systems theory is discussed in connection with acquisition processes (Section 5.5). The end of the chapter returns to the idea of representation, refining how the concept is used in this research by connecting schema theory with the templatic approach and dynamic systems theory.

5.1.1 The generalization commitment

Modern linguistics divides the study of language into distinct areas: syntax, phonology, morphology, semantics, and pragmatics. The generalization commitment of cognitive linguistics, however, holds that all areas of language are bound together by common structural principles (Evans & Green, 2006; Lakoff, 1991; Langacker, 1987). While concerns of practicality and focus can render the study of distinct subsystems advantageous, cognitive linguistics maintains that strict divisions between the subsystems likely do not exist. One argument in support of this concerns research revealing fuzzy boundaries between categories and graded category membership (Lakoff, 1987; Rosch, 1999) in structures belonging to each of the subsystems. For example, the psychological reality of the binariness of phonological features has been challenged (Jaeger & Ohala, 1984), suggesting that phonetic content is graded by nature. Gradient structure in morphology (Hay & Baayen, 2005) and in syntax (Bresnan & Hay, 2008; Taylor, 1998) has also been reported, as well as in semantics (Coleman & Kay, 1981; Rosch, 1975). These findings point to shared organizational features across each of the components of language (Evans & Green, 2006). Categorization findings are not the only support for the generalization commitment but are highlighted here because they extend informatively to phonological categories (e.g., templates, phonemes, features), which are at the center of the present research.

5.1.2 The cognitive commitment

Cognitive linguistics places emphasis on what is known about the cognitive capacity for categorization, a point central to the cognitive commitment. The cognitive commitment characterizes cognitive linguistics, particularly when considered in contrast with generative linguistics, which assumes language to be a modular system formalized by symbol manipulation (Lakoff, 1991). As Lakoff (1987: 5) points out, “There is nothing more basic than categorization to our thought, perception, action, and speech”. Research dispels the classical conception of categorization defined by essential membership characteristics and clear boundaries in favor of a more psychologically realistic view of fuzzy boundaries and graded membership (Rosch, 1975; 1978), in support of a cognitive theory of language. Human beings display a natural tendency to recognize similarities and differences between things and to group them accordingly, and cognitive grammar argues that the principles of linguistic structure should reflect what is known about cognitive processes.

5.1.3 Embodied cognition

Another related concept important to cognitive linguistics is embodied cognition, which concerns the bodily basis for all mental processes. The position cognitive linguistics takes on this issue runs counter to the mind/body dualism of Descartes and conflicts with the stance of generative grammar that language can be studied purely as a formal system, separate from speakers and their bodies. In generative grammar, a child comes to the world endowed with abstract linguistic knowledge. In a theory of embodiment, the child develops abstract knowledge of concepts and categories by way of sensory-perceptual experience (Boyland, 2009; Evans & Green, 2006; Johnson, 1987; Mompeán, 2014; Smith & Gasser, 2005), tracing a path from specific usage events to abstract knowledge. Embodiment is discussed in Chapter 4 as a tenet, also, of dynamic systems theory (Thelen, 1995; Thelen & Smith, 1994) and so is not discussed further here.

5.1.4 The symbolic thesis

The symbolic thesis is fundamental to cognitive linguistics, stating that a language system is built on conventional pairings between form and meaning called symbolic assemblies (or constructions—Goldberg, 1995). In this way, the symbolic thesis has its roots in the Saussurean sign associating a concept with a phonological structure, but should not be conflated with structuralist movement that followed Saussure (Taylor, 2002: 39). Rather, while Saussure and the proponents of cognitive grammar recognize language as a symbolic system, the two can be distinguished. While Saussure acknowledged a single linguistic object for study (i.e., the linguistic sign), cognitive grammar acknowledges three components: symbolic units, phonological structures, and semantic structures (Taylor, 2002: 53). Phonological and semantic structures can be considered independently; it is by convention that they are associated as a symbolic unit. Cognitive linguistics further extends the idea of the linguistic sign (i.e., symbolic unit) by applying it to units larger than words (Evans & Green, 2006). A symbolic unit—"the construct deployed in cognitive grammar for the representation of both lexical and grammatical structure" (Langacker, 1987: 58)—combines with other symbolic units to form larger and larger structures, like phrases and sentences. While symbolic units represent a range of conventional expressions, schematic symbolic units represent grammatical patterns, which differ from symbolic units in being less specified (Evans & Green, 2006; Langacker, 1987). For example, the concept *tree* has a semantic pole identified with the idea of a thing with a trunk, branches, and leaves, and also a phonological form [tri:]. By conventional pairing, the semantic pole and the phonological pole form a symbolic unit (or symbolic assembly; or construction). An example of a schematic symbolic unit is, in terms of syntactic structure [P[NP]], which renders any number of phrases including a preposition followed by a noun phrase; in terms of morphology [VERB-ed], which results in regularly formed past tense verbs in English; and in terms of phonology, [CVC], which results in any words consisting of the pattern of consonant-vowel-consonant.

In acquisition, children must acquire knowledge of the conventional associations comprising symbolic units and "[construct] utterances out of various already mastered pieces of language of various shapes and sizes, and degrees of internal structure and abstraction—in ways appropriate to the exigencies of the current usage event"

(Tomasello, 2003: 307). When acquiring language, a child acquires symbolic units, learned from the structures that occur in the language in use, and begins to exhibit creativity spurred by the emergence of complexity and abstractness in his or her linguistic system. The present research focuses on the phonological pole of symbolic units, leaving to future research the semantic pole and conventionalized relationships between the two poles in a given unit.

5.1.5 A usage-based model

Cognitive linguistics, like dynamic systems theory, operates on usage-based principles within an emergent framework. Up to now, this chapter repeatedly refers to language in use. This is because the theories brought together in this research recognize the influence of linguistic patterns as they are used and perceived on the continuous reorganization of a mental grammar. Usage-based models propose minimal innate structures, upon the claim that knowledge of linguistic structure is acquired from language use in connection with general cognitive capabilities (Langacker, 1987; Langacker, 2000; Mompeán, 2014; Tomasello, 2003). In this formulation, children must learn a great complexity of linguistic structures and patterns from scant beginnings, in contrast with nativist models claiming that innate structures specified for language must be present in order for a child to acquire a system as complex as a language, which minimizes what must be learned. According to Bybee (1999: 215), "Emergentist and connectionist views of language take substance (or the perception and memory of experience with substance) to be directly represented, while structure is considered emergent from the way substance is categorized in storage, which in turn is based on patterns of actual language use". What is learned includes not only the structures of language, but also the conventionalized use of a symbolic unit tied to its semantic and pragmatic uses within a speech community (Bybee, 2001; Mompeán, 2014). Reconceptualizing grammar as built on usage-driven constructions rather than partly on rules and partly on irregular forms is an advantage of usage-based over nativist models of grammar (Boyland, 2009). In the process of constructing a grammar, abstract linguistic categories develop bottom-up from concrete usage events (Behrens, 2009; Langacker, 1987; Taylor, 2002) both in acquisition and in language processing beyond the initial stages of acquisition. A consequence of this for phonology places phonological and phonetic information on a continuum, dispensing with the traditional distinction between the two subfields.

5.2 Phonology in cognitive linguistics

Among the subfields of linguistics, phonology has received the least amount of attention within cognitive linguistics. Even Langacker (2000) notes not fully having explored phonology within the parameters of cognitive grammar, but cognitive phonology has nevertheless gained ground in more recent work (see Mompeán, 2006). Langacker (1987) devotes some space in his *Foundations of Cognitive Grammar* to phonology and, later, questioning the cognitive reality of step-by-step derivational processes, Lakoff (1993) presents the beginnings of cognitive phonology as an alternative to rule- and derivation-based phonological theories. Lakoff (1993) describes—rather than serial-ordered rules—the simultaneous deployment of relevant constraints acting on phonological representations, which results in phonetic forms, in what shares a quality of nonlinearity found in Optimality Theory (Prince & Smolensky, 1993-2008). Rather than static underlying representations, cognitive grammar is built on constructions—schematic complex categories that integrate the phonological and semantic components of a given unit, represented hierarchically in the grammar "at appropriate levels of abstraction" (Langacker, 1987: 409-410). The conceptualization of schematic phonological categories is detailed later in this chapter.

Lakoff (1993) presents a cognitive grammar analysis of several well-known phonological problems, which previously received a rule-ordering treatment, in order to exemplify cognitive phonology as a simpler and more realistic approach. These include an /e/-epenthesis rule in Mohawk, a few challenging phenomena in Icelandic, and Grimm's and Verner's Laws.[1] Although the argument is not explicitly made in Lakoff (1993), cognitive phonology differs from Optimality Theory. In Becker and Tessier's (2011) formulation, some constraints are innate while others emerge as a child learns a language. Cognitive phonology, however, does not consider constraints to be part of a Universal Grammar—rather, linguistic structure and constraints upon structure emerge from specific instances of usage. In addition, a cognitive approach to phonology asserts that language happens in real time and that temporality must be incorporated into a satisfactory theory of language (Bybee, 1999). Furthermore, the structural constraints proposed by cognitive phonology are phonetically motivated (Bybee, 2001; Mompeán, 2014: 265; Nathan, 2008: 154)—an argument found also in the tenets of Natural Phonology (Donegan & Stampe, 1979). Lakoff (1993) suggests that cognitive phonology probably best fits a connectionist framework, with variable levels of activation between

[1] These are not described in detail here. Lakoff (1993) is introduced here only to provide an example of early cognitive phonology work as part of a timeline for this subfield of cognitive grammar, and a detailed description of the examples provided in the article do not advance the argument presented in this research.

linguistic units, but does not devote space in the chapter to fleshing out the idea. As noted in Chapter 1, a connectionist approach hosted by a dynamic systems framework may offer a suitable mechanism for linguistic processes; the present research, however, focuses on the compatibility of dynamic systems theory with the templatic approach and schema theory and on the way the three theories uniquely supplement each other.

Beyond Lakoff (1993), other researchers (e.g., Kristiansen, 2006; Mompeán-González, 2004; Nathan, 1986; Nathan, 2008; Välimaa-Blum, 2005) have built on the impulse to reflect what is known about cognition in phonological analysis, looking to the general cognitive capacities of categorization, perception, and conceptual combination (Bybee, 2001; Mompeán-González, 2014). Evidence of the prototype structure of categories, in which some members of a category are perceived to be better representatives than others, has been reported (Lakoff, 1987), even among children (Rosch, 1973). For example, a robin is generally agreed to be a better representative of the category *bird* than is a duck. Bybee (2001) points out that the same principles that apply to semantic categories within cognitive linguistics also apply to the phonological categories (e.g., phonetic sequences, segmental units). Kristiansen (2006) refines a description of phonological categories in terms of prototypes, advancing the ability of cognitive phonology to account for the rich phonetic detail found in speech concerning sociolinguistic variation. Mompeán-González (2004) argues that both the radial category model (Lakoff, 1987) and the network model (Langacker, 1987) can be effectively used to describe phonological structure. A radial category consists of a centrally positioned, idealized prototype, from which variants of the prototype extend, rendering a wheel-shaped larger category (Evans & Green, 2006; Lakoff, 1987). A network model is similar but more complex, subject to different kinds of categorizing relationships between members, including extensions from a prototype and relations between abstract schemas and more detailed instantiations (Evans & Green, 2006; Langacker, 1987). The latter is better positioned to account for the rich complexity of early phonological data because it allows for a range of variability in categorizing relationships; it is employed in the present research to depict emerging phonological organization during the templatic period.

5.3 Acquisition in cognitive linguistics

Far more cognitive linguistics literature has been devoted to the structure and processes proposed by in cognitive linguistics than to the acquisition of these structures and processes. This is, in part, for good reason since the generative approach to linguistics has long been set so firmly in place and a new theory must be thoroughly articulated based on sufficient linguistic evidence. Nevertheless, any theory of language must be capable of incorporating notoriously challenging child language data. Taylor (2002: 27) comments on the relationship between a child's input and the acquisition process: "It is assumed that the input to language acquisition are encounters with actual linguistic expressions, fully specified in their phonological, semantic, and symbolic aspects. Knowledge of a language is based in knowledge of actual usage and of generalizations made over usage events". A child must learn to perceive and interpret the full range of information transmitted by linguistic expression, including how and when it is used in communication, beginning with specific instances from which a speaker generalizes a pattern for subsequent use.

While the literature in cognitive phonology is somewhat limited, the literature on phonological acquisition within cognitive linguistics is yet more limited. Valimaa-Blum (2005: 58-60) devotes a few pages to the way a child develops abstract phonemic categories, and Kristiansen (2006) highlights the need to investigate sociololinguistic concerns in phonological acquisition. In his textbook on a cognitive grammar approach to phonology, Nathan (2008: 153) dedicates a short chapter to both first- and second-language acquisition within cognitive phonology, arguing that a usage-based account of phonology is not capable of describing the "behaviors that children exhibit while acquiring language and that adults exhibit while producing it" (Nathan, 2008: 153). He offers Smith's (1973) study of Amahl and his own observations about an English-acquiring child he observed. For example, for a period of time, the child regularly replaced voiceless dental fricatives (/θ/) with labiodentals (/f/) (Nathan, 2008: 153). He questions why a child would replace more marked segments with less marked segments since a child does not hear these sounds in the ambient language, and concludes that conceptualizing phonemes as "calls to motor routines" (Nathan, 2008: 154) can explain "why children alter the routines, leading to replacements in every relevant word". Since the argument is not elaborated further, offering detailed commentary is not possible. What is seen in templatic research, however, illustrates that different processes affect and contribute to the construction of a phonological system at different points along the way. The age of the child Nathan (2008) describes is not given, and data for Amahl (as discussed in Chapter 2) are either from the end of the templatic period or beyond it altogether. Evidence for the usage-based nature of phonology is found, in part, by closely examining a child's complete system in development, and this information is not provided for either child to which Nathan (2008) refers. Contrary to Nathan's (2008) statement, the templatic approach incorporates findings from research on babbling, the onset of word production, and cognitive development (as presented in Chapter 3), and supports a usage-based approach to the acquisition of language in general and of phonology in particular.

Some important questions introduced by Langacker (2009: 628) need to be examined if we aim to understand how language is acquired: "How are linguistic patterns abstracted from usage events? What precisely is abstracted? In what form is it stored or represented? How is it then used?". The answers to these questions may differ at different points in acquisition. As was described in Chapter 3 concerning templatic behavior, there is evidence that the nature of the units of phonological representation changes during the course of acquisition. That is, whole-word templates seem to play a prominent role as a phonological system is first built, later giving way to predominantly segmental knowledge. Describing templates in terms of schematic structure of varying degrees of abstraction begin to answer the latter three questions. Again, as described in Chapter 1, a phonological system defined as a dynamic system is not built on degrees of abstraction, but rather on behavioral patterns of varying schematic utility. Conceptualizing evolving representational units—or preferred behavioral configurations—from a cognitive perspective begins to answer the first question of how patterns are abstracted from usage events. Across the domains of cognition, humans display a propensity to group together items of similar and different characteristics—to categorize, and the impulse to communicate counterbalanced by a drive for cognitive economy forges the generalization of patterns across specific instances (Goldstone & Kersten, 2003). The present research seeks to contribute to cognitive linguistic research by filling gaps in the literature where phonology and acquisition meet. The following sections describe schema theory in more detail, specifically how it is employed in the present research to provide clearer representational structure to the units of an incipient phonological system.

5.4 Schema theory

5.4.1 The basic concepts

There is precedence for proposing the phonetic beginnings of abstract phonological systems (e.g., Hayes, 1999; Lindblom, 1999; Vihman & Velleman, 2000)—that is, for actual usage events to serve as the phonetic seeds from which generalizable phonological categories grow. In this formulation, phonological categories are phonetically motivated (Bybee, 2001; Mompeán, 2014: 265; Nathan, 2008: 154), and phonetic and phonological content exists on a continuum running from less abstract (low-level) usage events to more abstract (high-level) mental categories. A cognitive approach to grammar "employs fully articulated schematic networks and emphasizes the importance of low-level schemas" (Langacker, 1987: 494). This is because it is the low-level usage events that are generalized to new usage events, resulting in the formation of abstract categories. As Lindblom (1999: 13) puts it, "For the child, phonology is not abstract. It represents an emergent patterning of phonetic substance." In fact, previous research reveals that prelinguistic babbling patterns influence the sounds in early word production patterns (Cruttenden, 1970; Elbers & Ton, 1985; Jaeger, 1997; Macken, 1979; McCune & Vihman, 1987), which constitute this phonetic substance. Among early word forms, patterns affecting whole words (i.e., templates) have been observed to be the first organizational units of representation in acquisition (Ferguson & Farwell, 1975/2013; Macken, 1979; Priestly, 1977/2013; Waterson, 1971; Vihman & Croft, 2007). The nature of templatic representation, however, has not been precisely defined, and the idea of holistic representations has been criticized for being variable, vague, and lacking precise structure (Fikkert, 2000).

Schema theory, as described within the cognitive grammar framework (Langacker, 1986; Langacker, 1987), offers a clear way to provide templates with structure, while also capturing dynamically variable degrees abstraction as linguistic representation is redefined in real time. In a cognitive grammar, all aspects of grammar are driven by the schema (Langacker, 1987: 328), and a process of schematization entails the process of pattern extraction and generalization that contributes to the construction of a linguistic system (Langacker, 2009; Tomasello, 2003). The related concept of a schematic network allows for the depiction of emerging schemas in relationship with one another and models a system of schematic categories, which have variable degrees of abstraction and are connected by categorizing relationships.

Cognitive phonology as a branch of cognitive grammar describes the structure of phonological categories and relevant processes (Langacker, 1987; Nathan, 2008; Taylor, 2002), but this developing field lacks research on first-language acquisition, specifically that involving rapidly evolving whole-word patterns found in early child data. While the phonemic category and allophonic variation have been discussed in prior work (Kristiansen, 2006; Langacker, 1987; Mompeán, 2004; Taylor, 2002), it is not clear how word-shaped templates in early child word production fit into this picture or how a path develops from there to a more systematic, likely segment-based, phonological system.

The present research employs the tools of cognitive grammar to model the dynamically developing categorizing relationships involved in this transitional period by depicting templatic patterns in child data as schemas in continuous interaction in an incipient phonological system. Tomasello (1995; 2000; 2003) describes a dynamic process of schematization in language acquisition, with a focus on syntactic patterns, but does not address phonology. Thus, the project presented here addresses two gaps in the usage-based literature on language acquisition: acquisition within the field of cognitive phonology, and phonology within a usage-based approach to language acquisition, specifically attending to schematization processes[2]. The use of schema theory facilitates a clear depiction of degrees of abstraction—or, changing levels of stability or preference, in a developing phonological system. For ease of reference, "degrees of abstraction" is predominantly used in this work, but it is important to bear in mind the processual nature of these entities.

5.4.2 Schematic structure and networks

Defining a schema as it used in this research—and, further, a schematic network, brings clarity to the connection proposed in this research between templates and schemas. Also important is justifying the motivation for uniting schema theory with the templatic approach to phonological acquisition. Because templates are devised as *schematic* units of representation affecting whole words (Vihman & Croft, 2007), it is essential to make clear why the two theories should be brought together. Both schemas and templates are conceived as representational units in the grammar, which loosely constrain instances of

[2] While the approach presented in Vihman and Croft (2007) is rooted in a constructionist framework, it does not incorporate schema theory as a way of structuring templates or their development.

language use. The similarities between a schema and a template demonstrate the compatibility of the two theories, and the differences illustrate how schema theory nicely supplements the templatic approach.

In Chapter 3, templates are described as partially detailed units of representation that affect whole words in production, which are fleetingly routinized in early phonological development to facilitate the production of words. Their composition and degree of productivity change in response to a child's experience with the ambient language. The template and the schema share the characteristic of being partially detailed units based in the cognitive and motor systems. In view of the argument that actual instances of usage serve as the necessary roots of a child's incipient phonological system, an account of how templatic patterns make the transition between phonetic form and abstract representational unit has not been devised. Schema theory depicts complex categories that represent various and varying degrees of abstraction. Defining the phonological templates found in early acquisition in terms of schematic structure facilitates the visualization of patterns in use that change in degree of abstraction, interact with other patterns, or dissolve altogether. Furthermore, while the use of a template to produce a given word has some concern with the relationship between the child representational unit and the target phonetic form, schema theory completes the picture by giving structure to the instantiation of a representational unit in speech.

A closer look at the structure of a schematic symbolic unit helps to make these concepts more clear. Phonological units, as part of the phonological and not the semantic pole in a symbolic unit, do not themselves have meaning. They can be thought of as subordinate to symbolic units (Välimaa-Blum, 2005: 17), but they play an important role in linguistic expression as a means of lexical contrast. Langacker (1987: 328) describes phonological structure as part of the phonological pole in a symbolic unit, parallel to the semantic pole and requiring “essentially the same apparatus for…description” as that for semantic structure. That apparatus is the schema, a cognitive-motor unit lacking in detail, which constitutes the way grammatical patterns are represented (Langacker, 1987: 58). Specification of schematic detail is achieved in the instantiation of schemas (Langacker, 1987: 81-85), and schemas can be described as product-oriented in that the schema generalizes over a number of instances of a given category but does not specify how to instantiate the schema (Bybee, 2001: 126; Taylor, 2002). As a result, the speaker is granted some creativity in this process. By contrast, in a rule-based theory of how novel forms enter a language, involving source-oriented abstract rules, some forms will not be allowable products of a given rule. Unpredictable forms do, nevertheless, occur in speech, and this is especially the case in the earliest stages of child language, for which a usage-based approach to language is able to account.

To illustrate the relationship between schemas and their instantiations, analogy can be drawn between these concepts and the superordinate and subordinate nodes in a taxonomic hierarchy (Langacker, 1987: 68). This idea is exemplified by the relationship between the concepts of a *bird* and a *duck*. Like a superordinate category (here, *bird*), a schema defines a category lacking in specificity to which more specific subordinate members (i.e., instantiations; *duck* in this analogy) belong, and these members (i.e., instantiations) are compatible with the specifications of the superordinate category (i.e., schema). Like the more general concept *bird*, a duck is covered in feathers, has wings, and lays eggs, but it also has other features that are not specified (e.g., a bill instead of a beak, little superficial similarity to birds seen at feeders and in trees). Importantly, instantiations are not required to maintain exact identity with a schema. This is why many kinds of birds can be part of a more general, more abstract *bird* category, including the duck, which likely is not among the first representatives of the category to come to mind when one thinks of a bird.[3]

Representational units of the grammar license patterns of usage, affecting the way a schema is realized in language use (Evans & Green, 2006; Langacker, 1987). That is, an instantiation of a schema as an instance of usage can be either fully or partially sanctioned by the grammar. If an instance of usage is fully sanctioned by a schema, it maintains the identity of the elements specified in the schema. An instance of usage that is partially sanctioned by a schema deviates in some aspects from the identity of the elements specified in the schema. Partially sanctioned instantiations of a schema tend to result in innovative language use. For example, Evans and Green (2006: 116) offer the example of *mouse* in English. An instantiation of the schematic unit comprised of phonological and semantic information about the rodent is fully sanctioned where the concept of a small rodent is intended in connection with the phonological form *mouse*; partially sanctioned instantiation of the schema results, for example, in the use of the phonological form *mouse* paired with the extended meaning that refers to a computer mouse, which is similar in shape to the rodent. This concept of sanctioning describes how schematic units bearing some degree of abstraction give way to a variety of more specifically detailed symbolic units in language use.

[3] Here mental categories rather than conventionalized scientific taxonomies are intended.

The current research attends only to the phonological pole in schematic symbolic units and focuses on the instantiation of phonological schemas without distinguishing between full and partial sanction. As such, the notion of schema instantiation nicely supports the connection between phonological templates and phonetic forms in production, completing the relationship between the target form, the developing representational unit, and the child form. Both selected and adapted template use can result in forms fully sanctioned by the schema. When a template selects a word for production, the target phonetic form bears close resemblance to the contents of the template as a schematic unit. In the condition of selected use, instantiation of the schema, then, results in a child form that contains the units specified in the schematic representation *and* closely match the target form. Adapted use of a template targets words for production whose phonetic forms contain units that diverge from those specified in the representational unit. In the condition of adapted use, unexpected child forms tend to result from the instantiation of the schematic unit. This is because the child forms are sanctioned by the schematic pattern, which does not exactly match the target form to which the schematic template adapted in production.

As laid out in their respective frameworks, template use requires some perceptual knowledge of the target phonetic form, and the schema comes into play in the deployment of its representational details in production. An example is offered here, using the labial-velar pattern found among Djuna's data (reported in Chapter 7), in (1):

(1)	*Target form*	→	*Template*	/	*Schema*	→	*Child form*
	[blækhɑks]		**selected use**				[bɪka]
			LAB-VEL	/	[labC]V[velC](V)		
	[bʌbl̩]		**adapted use**				[bʌku]
			LAB-VEL	/	[labC]V[velC](V)		

The templatic pattern and schema are included together to show their notational differences, but they should be considered to be one representational unit. The pattern is defined by a non-consecutive sequence of a labial and a velar consonant. As a template, the pattern is more loosely name LAB-VEL. Reconceptualized as a schema, the pattern is given clearer structure in order to show the emerging organization and relationships between patterns in the developing system. The relationship between the target form, template, schema, and child form is not quite linear as the depiction in (1) suggests. Rather, with some perceptual knowledge of a target form, the child selects a word for production based on schematic details in a representational whole-word template. The schema is deployed in production efforts, which results in various instantiations. Both perception and production efforts continuously affect the stability of the representation. For clarity, the depiction above shows only one instantiation for *Blackhawks*, but the child produced five different utterances—four of which are sanctioned by the LAB-VEL schema, during the first month of word production.

Frequency of usage entrenches a given schematic pattern along a continuum of variable abstraction, and schemas of greater abstraction can be extracted, generating a hierarchy of schematic structures that shift as a function of language use. The utility in uniting schemas with templates, in fact, is found in the capacity for schema theory to supply templates with hierarchical structure based on the relationship between frequency and entrenchment. Evans and Green (2006: 116) offer a clear explanation of how this works:

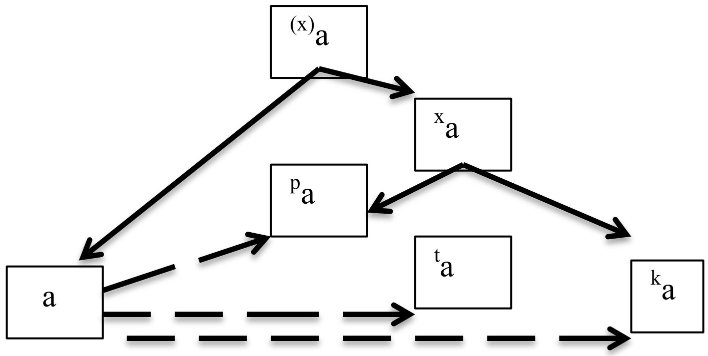
> ...if a particular linguistic structure recurs sufficiently frequently, it achieves the status of an entrenched unit. As a result of the process of entrenchment, schemas

> result that have different levels of schematicity. This means that some schemas are instances of other, more abstract, schemas. In this way, the grammar acquires an internal hierarchical organization where less abstract schemas are instances of more abstract schemas. (p. 116)

Templates are purported to evolve and change as a child acquires new phonological information from his or her ambient language, and this intuitively makes sense. It is not clear, though, what processes or structures drive these kinds of changes. Schema theory introduces to the templatic approach the notion of hierarchical organization based on degrees of schematicity, as a function of the frequency-driven entrenchment of usage patterns. Schema theory, furthermore, provides a structure by which these patterns can be seen to interact as a phonological system evolves.

Extending schematic analysis to include schematic networks (Langacker, 1987) further befits analysis of the acquisition data under scrutiny here. A schematic network is a complex category constructed from schematic nodes (i.e., representing a discernable pattern) connected by categorizing relationships (i.e., identification of certain patterns as extensions from others) that are based on full or partial sanction of a given schema (Langacker, 1987: 411). In terms of phonology, these categorizing relationships may be specified to features, segments, or larger phonological patterns. For example, Langacker (1987) conceptualizes the phoneme as a schematic network, with allophonic variations positioned as nodes. Suggesting that children learn syllables before segments, Langacker (1987) offers the phoneme /a/ as an example of an emergent schematic network (see Figure 5.1).

Figure 5.1 Schematic network for the phoneme /a/.



(Adapted from Langacker, 1987: 390)

In this example, /a/ is the phoneme, and [^{x}a] is the schema from which the allophonic instantiations extend, and [$^{(x)}$a] is more abstract than [^{x}a] because it provides the option for the presence or absence of a consonant transitioning into the vowel. An emerging system of such networks composes a complex phonological system as a child categorizes and re-categorizes linguistic information in response to his or her evolving experience with the ambient language. This phonemic model, which incorporates allophones as they occur—specified for onset transitions, forecasts the applicability of a schematic network to templatic representation. Chapter 8 presents two emerging schematic networks, which represent some of the early-developing phonological patterns found in the data examined for this research, and which begin to interact as the child acquires additional phonological knowledge.

5.4.3 A process of schematization

The present research aims to address not only the structures involved with a developing phonological system, but also the development of the system's units in a temporal context. Because of this, it is pertinent to emphasize that emerging structures containing phonological knowledge are in the early processes of formation and evolve rapidly. Phonetic information enters into the developing abstract system by way of a process described here as schematization, which involves the generalization of a category across multiple instances of usage, resulting in a more abstract and less richly detailed category.

With this concept in view, the definition of a schema and how it is used in this research can be further refined. Taylor (1990: 526) describes schemas as structures that "emerge through a person's ability to recognize what is common to different uses of a linguistic sign". Children acquiring language learn to recognize what it means for things to share certain qualities and to be able to categorize them accordingly. This entails a developing ability to categorize the elements of language across "instances of usage" in an emerging abstract system for the purpose of effective and accurate communication; these instances of usage become "routinized…patterns of experience" which assist a child in the acquisition process (Kemmer, 2003: 78). This is the case in many aspects of development, and not only with language. Upon taking the steps to do something new (e.g., walk, use a spoon, produce words), children require many "instances of usage" in order to successfully learn a task and the processes involved with it. Children practice new tasks, establishing routines and entrenching new cognitive structures of varying degrees of abstraction.

This point addresses the important quality of schemas as having degrees of abstraction. That is, the schema is not merely an abstract cognitive structure; rather, it is a functional unit that can vary in degree of abstraction dependent on the speaker's ability to categorize across instances, either extracting more general schemas or making finer distinctions (Langacker, 1987: 382). The schema is also, importantly, a motor unit involving the signals that direct the execution of an articulatory plan for a given sound or sequence of sounds (see Langacker, 1987: 112-113). When a schema is productive, its contents become more abstract and generalized enough to be applicable in multiple instantiations; making finer distinctions results in new schemas with new and less abstract specifications. As an example, data presented in Chapters 7 and 8 illustrate the use of a SIBILANT template (i.e., (C)V<sib>, optional consonant followed by a vowel and a sibilant consonant), which becomes increasingly abstract as it is used to target for production an increasing number of words, resulting in varied instantiations and, subsequently, the creation of several subschemas that are less abstract.

The process of schematization described in Tomasello (2000) begins with imitation, wherein children begin to imitate chunks of language to which they are exposed. Tomasello (2000: 70) emphasizes that when children begin to produce units of language in an "adult-like way" it is more than mere imitation; rather, children are reproducing communicative function along with the superficial linguistic form. This is important because it highlights the primacy of meaning and contextual information, which is central to the tenets of a cognitive approach to language and is key in arguments for whole-word phonological patterns being the primary unit of early acquisition rather than smaller units like segments or features. If the primacy of meaning in language use is accepted, then it becomes clear why children with limited phonological knowledge might use partially detailed patterns affecting a whole word (i.e., templates) rather than drawing from individual sounds or features to target words for production.

Building on the imitation stage of the process, linguistic expressions that children hear and use with any frequency become entrenched in a developing linguistic system, a process that constrains which expressions enter into the abstract system (Tomasello, 2003: 295). While this might lead to some stability with language use, it also leads to the incorrect overgeneralization of patterns and other similar struggles that children may encounter in attempts to accurately produce language in accordance with what they hear. Because children eventually come to produce linguistic expressions beyond what they hear, however, they must at some point abstract linguistic information from instances of usage that can be generalized to novel expressions.

While Tomasello (2000; 2003) focuses on syntactic data, the schematization process he describes can be applied also to phonological data. Tomasello (1995: 151) describes children's first word combinations as having a "frame-and-slot" schematic form. That is, for early linguistic structures children make use of the limited set of tools available to them and have not yet made full use of categorization skills that would enable them to establish more generally applicable categories. Instead they use a schematic frame and begin to fill in slots with the limited knowledge they have acquired. Templatic or schematic phonological forms can be thought of in this way. For example, a list of utterances for *giraffe* (produced by the child Djuna, studied in the present research), illustrates the "frame-and-slot" idea. During this period of time, the child produced a multitude of utterances for *giraffe*, in (2):

(2)	[ʒʌwa]	[ʒa]
	[ʒʌʒa]	[ʤa]
	[ʒua]	[ʤæ]
	[dʒia]	[ʤæʃ]
		[ʤæʧ]

Those in the first column were produced within seconds of each other on the same day near the end of the child's first month of word production, as if she were trying out each variation in attempt to match what she had perceived in adult speech, filling in the empty slots in a highly schematic frame—with only the phonological units available to her at the time. These units included basic syllable patterns (e.g., CVCV, CVV, CV, CVC), a HIGH-LOW V pattern (described in Chapter 7), and a limited repertoire of sounds.

This example is illustrative of what details might be specified in a phonological schema, how a schema is used to produce words in the early stages of phonological acquisition, and how a process of schematization might proceed. Taylor (2002) provides further insight into schema-instance relations, arguing that schemas develop for patterns of instantiation and also for patterns of extension. For example, there is a relationship between the allophonic instances [p] and [p^h] with the schema /p/, and there is an additionally clear connection between this relationship and that between the allophonic instances [t] and [t^h] with /t/ and [k] and [k^h] with /k/—that of a more abstract and less detailed schema depicting the relationship between a VOICELESS STOP and lower level UNASPIRATED ALLOPHONE and ASPIRATED ALLOPHONE. Early child phonology data containing whole-word patterns can be comparably represented. Along these lines, Chapter 8 offers schematic depictions of the templatic patterns found in data examined for the present research.

5.4.4 Schema vs. analogy in the formation of novel expressions

Schema theory in the context of early phonological acquisition data finds itself uniquely capable of addressing the long-standing controversy schematic and analogical processes in the formation of novel expressions. The two kinds of processes are considered by some to be two distinct operations, while some argue to varying degrees that the processes are one and the same. The main concern is whether the speaker forms a novel expression based on a concrete instance or on a generalization across instances abstracted to a schema. The position taken here is that the two kinds of processes exist on a continuum and, as such, cannot usefully be distinguished.

Positions on the issue range from claims that only one or the other process is viable to various claims positing a continuum situating each process at either end. Some consider the two processes to be distinct. Gick and Holyoak (1983) describe the schema as a mediator for parts of an analogy, and depict the two kinds of processes as distinct but intimately related. Because, the authors note, contained in the schema are only the details that are similar between analogous elements and not their differences, a schema facilitates analogical processing by increasing the salience of details that trigger the deployment of analogical processing. From an experimental study employing computational methods to address morphology, Albright and Hayes (2003) conclude that analogical processes are not sufficient to produce morphologically complex words. They argue that only abstract properties (i.e., rules) can account for both regularly and irregularly formed complex words more consistently than either analogical processes alone or a dual-mechanism model (see Pinker & Prince, 1994) in which regularly formed words are handled by rules and irregular by analogy. In contrast, Krott (2009) shows that noun-noun compounds can be ascribed only to analogical, not to abstract rule-based, processes. This is in addition to exceptional or irregular forms often ascribed to analogical operations.

In an analysis of the formation of morphologically complex words, Booij (2010) presents evidence for the absence of a clear boundary between analogical and schematic processes. He proposes a continuum based on degrees of abstraction, on which the two processes sit at opposite ends: analogy at the least abstract and schemas at the most abstract end. Booij (2010: 94) offers the example of *Watergate* and compounds that employ the *–gate* part of the word in the formation of novel compounds to illustrate degrees of abstraction and, thus, rich schematic structure, that evolve with novel uses of *–gate* in compound words.

A continuum is a reasonable solution when we consider that each process involves the detection, extraction, and application of a pattern. Langacker (1987: 447) takes the argument further, however, concluding that there is "no substantial difference" between the two kinds of processes, pointing out that each requires that the speaker perceive a pattern and that the only distinction between schematic and analogical processes is whether the speaker has encountered the construction a sufficient number of times to be able to extract the schema and form an abstract unit. If the speaker has not already established a schema, he or she can activate relevant acquired forms, performing an analogical process, and then extract the schema; if the speaker has already extracted a given schema from previous instances, then it can be used to generalize to the novel form, and stored forms need not be activated for the purpose of constructing a novel form.

When the rapidly evolving nature of language acquisition in children is factored in, this is a reasonable conclusion. Especially for an infant just acquiring language, generalization across instances into an abstract entity in the cognitive system must begin somewhere – perhaps with a single instance. It is not clear how many instances are required in order to generalize to a schematic category (see Tomasello, 2006: 47), but for the child with an underdeveloped capacity for categorization, there are likely to be fuzzy areas where it is not clear whether a distinctly analogical or schematic process is being used. Beyond first language acquisition in children, Hofstadter and Sander (2013: 335-336) illustrate the fuzziness between analogical and schematic processes with the capability of one-member categories to be pluralized. For example, a specific entity (e.g., Wordsworth) can be used to refer to a general category (e.g., Wordsworths) that could include only a few or hundreds of instances. In this case, Wordsworth is a one-member category including the famed Romantic poet, but the name can be pluralized to refer to poets of comparable stature and impact in a given literary period. The authors argue that because the entity can be pluralized and used in the abstract, and because the number of instances has the potential to vary greatly – as a schema – no firm distinction can be drawn between the use of a concrete and abstract concept to which a person has access.

Ultimately, Hofstadter and Sander (2013: 337) assert that analogical and schematic processes are one and the same: "…in both cases, what is going on is an act of analogical mapping that builds a link between a fresh new mental representation and an older mental representation stored in our brain". In the early production data presented in Chapter 7, at first there is one instance of a given pattern (e.g., LAB-VEL, a whole-word consonant pattern), and then a second instance followed by a third, and so on. The proposal here is that a given template/schema gains in degree of abstraction along a continuum, with increased applicability in word production. Furthermore, viewing the process in close focus, and following the line of thought presented in Langacker (1987) and in Hofstadter and Sander (2013), there is no substantial difference between analogical and schematic processes in the creation of novel expressions. The reason this argument is important is that it allows for a microscopic look at sounds and sounds patterns as a child begins to use them and as they become more abstract units as part of an incipient phonological system, capable of being applied to new words a child attempts to produce.

5.5 Representation

The end of this chapter necessarily returns focus to the notion of representation. The point is made throughout this dissertation that what is typically termed "representation" should here be thought of as time-dependent states comprised of interacting processes. Representation constitutes the main difference between divergent models of phonological development, and the templatic approach aims to describe representation during a very specific period in the process of phonological development. Situating templates within dynamic systems theory highlights the temporal force active in language use and in the continuously evolving processes in real time, as defined in Chapter 4. Schema theory adds another dimension to the way templatic behavior can be more precisely defined to depict intricately detailed organization and processes by which early patterns change and interact in phonological development.

There are several important concepts that schema theory helps to emphasize within the templatic approach. One is that templates are not static but rather continuously change, subject to ambient-language influence. Adding nuance to this point is that templatic patterns—as viewed through schema theory—change in their degree of abstraction. Schemas are generalizations formed over numerous instances of usage, whose degree of abstraction is calibrated by the frequency of instances a child encounters. As dynamic systems theory does not employ the notion of abstraction, we can translate this notion of generalization to be compatible with dynamic systems theory by understanding "degrees of abstraction" as varying levels of stability in time-dependent states. Recall that schemas are functional motor "units" in addition to being cognitive, so it is not difficult to see how schemas can be thought of as behavioral configurations, as in dynamic systems theory. Furthermore, subject to effects of frequency, the degree of abstraction that characterizes a given schema at any given point is time-dependent. The range of specificity and generality in schemas renders useful the term "degrees of abstraction" in analysis, particularly for the sake of consistency among the literature, as long as the full scope of what is intended is understood. "Schemas may be formed at many different levels of generality," Bybee (2001: 32) observes, offering an example of the word *send*:

> The representation of a particular word, such as *send*, would be a very specific or local schema. A schema for the rhyme *–end$* is at a more general level of representation. Then there could be a more general schema for *–Vnd$*, and a still more general – *vowel-nasal-voiced stop$*, or even more general *–vowel-sonorant-stop$*, and so on. The presence of any of these levels of generality for a schema does not preclude the existence of others. (p. 32)

While the degrees of abstraction Bybee offers here are intended for a specific word, the hierarchy presented concerning degrees of abstraction in schematic representation applies to the present research. The basic idea here can be applied to early phonological patterns. For example, in data at the center of this research a SIBILANT schema (i.e., (C)V<sib>) is used; that SIBILANT schema is broken down into three subschemas each of which specifies a sibilant consonant (e.g., [s], [ʃ], [ʧ]). At a level of abstraction higher than the sibilant schema, a schema (i.e., (C)V(C)is) is proposed, which generalizes over the SIBILANT schema, an emergent subschema ending in [is], and a vowel schema (i.e., A_I). Chapter 8 illustrates how a child builds up a complex phonological system from limited beginnings.

In this way, schema theory—because it is compatible with the basic conceptualization of templates and the properties of dynamic systems theory—serves as a valuable and informative supplement to the templatic approach. Unifying the three theories enables the depiction of intricate processes in early phonological acquisition as interactive developmental processes evolve, subject to the influences of language in use in real time.

Chapter 6: Data sources and methodology

6.1. Introduction

Data from five sources were examined for this research. Analysis of four of those sources (i.e., Djuna, Trevor, Charlotte, E) is presented here to demonstrate important nuances that templatic analysis and, in coordination, schematic analysis can reveal in early phonological acquisition. Appendix A displays descriptive details for each of the four children. The fifth data source (i.e. Zachary; Smith, 2010) was excluded because the precise time for the production of each utterance in the crucial early period of word production is not as clearly defined as in the other sources due to the way that the data are displayed; this data, however, will likely be employed in studies extending the present research. The following sections provide general information about the use of sources and terminology in this research.

Data for Djuna were collected as part of a diary study conducted by the present researcher. Details for this study are provided in greater abundance than those for the other three studies. This is because the present researcher, also the mother of the child, conducted the study and full access to its details was possible; the other studies were conducted by other researchers at different points in time, and the availability of study details varies. Data for these three sources are located in PhonBank within the CHILDES database (MacWhinney, 2000; Rose & MacWhinney, 2014), and details of the study are given as reported on the CHILDES web site (http://childes.psy.cmu.edu/manuals/02english-na.pdf) and in relevant publications.

There may be some discrepancy between word count or lexicon size reported here and what is reported on CHILDES. This is due to differences both in terminology and in the way that words were counted, which should not affect the overall analysis. In this research, “word” refers to a phonetic form produced by a child in association with a clear referent the first time this referent is associated with a phonetic form. This form along with each subsequent production associated with that referent, regardless of the phonetic form, is called an utterance. New words and new utterances are numbered separately. The count of new words is used to measure a child’s lexicon size in order to make decisions about the relationships between changes in lexicon size and changes in patterns of template use. The utterance count is used to analyze template use over time and to calculate proportions of utterances using a template to utterances that do not use a template. The utterance count, rather than lexicon size, is used for the latter measures because doing so results in a view of distinct phonological patterns used to initiate new attempts at producing a given word.

The method for documenting utterances differs between the studies. For example, researchers studying E (Inkelas & Rose, 2003; 2008) and Trevor (Compton & Streeter, 1977; Pater, 1997) include multiple instances of the same utterances for a given word over the course of the study. While it is likely they did not capture every utterance, this method can elicit an estimation of the child’s preferred production patterns. Data collected from Djuna do not include multiple instances of each distinct pronunciation of a given word produced during the same period of time; however, when older pronunciations of a word were produced after a new pronunciation had been documented at a later point in the data, the older pronunciation was noted. The reason for focusing on first-time utterances was to be able to gain a clear view of when a template was used to initiate the pronunciation of a new word or a new pronunciation of an old word. Future work should make efforts to include as many utterances as possible—including repetitions—for the purpose of estimating the effects of frequency on the entrenchment of patterns in use (Bybee, 2001; Kemmer, 2003; Tomasello, 2003). Because this perspective was revised in response to this research, the present work relies on data reflecting only utterances when produced for the first time.

Differences in methodologies across studies prompted a reorganization of the data. Utterances were recounted in order to eliminate repeated instances of the same utterance for a given word. For example, numerous instances for Charlotte's pronunciation of 'again' as [əgɪ] are documented (Davis & MacNeilage, 1995; Davis et al., 2002). Reorganization of the data included only the first instance of this pronunciation of this particular word. This process was carried out for E, Trevor, and Charlotte for data collected during the months included in this study in order to achieve consistency with the data collection methodology for Djuna. Data for Djuna were subsequently reviewed to confirm consistency. Data counts and comparative measures are selectively presented in Chapter 7 and more fully in Appendix B.

Several colleagues assisted in the obtainment and organization of data from CHILDES that is used in this research. Using the organization scheme for data collected from Djuna as a model, Daniel Dakota, a computational linguist, wrote a program to extract and organize data located in the CHILDES database. The data files for Charlotte, Trevor, and E are stored in extensible markup language (XML) files, which define a set of rules for encoding documents that are both human- and machine-readable. The markup language defines a set of tags and embeds additional tags and information within a larger tag. The identification of a tag, its representation, and relevant information allows for a parseable structure. A program can then be written to extract the exact tag, and desired information can be extracted automatically.

The Python programming language was used to create a script to automatically scan all files of a particular speaker and extract desired information, with the Beautiful Soup module, a module designed to parse XML files. First, tags encoding pertinent pieces of information are identified. Then the information is stored in a dictionary and printed into a CSV-readable format, which can then be read as a CSV file. Two XML sample files used for the Charlotte data set are presented below. The first, in (1), is the meta-data containing information about each individual file:

(1)

```
<?xml version="1.0" encoding="UTF-8"?>

<CHAT xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
   xmlns="http://www.talkbank.org/ns/talkbank"
   xsi:schemaLocation="http://www.talkbank.org/ns/talkbank
http://talkbank.org/software/talkbank.xsd"
   PID="11312/c-00012276-1"
   Version="2.0.2"
   Lang="eng"
   Corpus="Davis"
   Id="cha28"
   Date="2004-10-21">
 <Participants>
  <participant
   id="CHI"
  name="Charlotte"
   role="Target_Child"
   language="eng"
   age="P1Y11M22D"

   sex="female"
```

The meta-data enables the extraction of general information from the file for this particular speaker. This information pertains to every utterance in the file, so whenever an utterance is extracted the meta-information can be used to categorize when and where the utterance was produced. For example, all utterances in this file were extracted on 10/21/2004 when the child was aged 1;11.22.

The second XML sample file contains the encoding of an individual utterance, presented in (2):

(2)

input

```
  <u who="CHI" uID="u15">
    <pg><w>cow</w><actual><pw><ph id="ph0">k</ph><ph id="ph1">a</ph><ph
id="ph2">ʊ</ph></pw></actual></pg>
    <t type="p"></t>
  </u>
```

output

target word	actual pronunciation
cow	kaʊ

In this sample, the utterance is identified by the “u” tag. Within each “u” tag, the speaker (“who”) and the utterance ID (“uID”) can be accessed. The target word appears within the “w” tags and the phonetic pronunciation appears within the “actual” tags, embedded within which is the individual phonetic character tag (“ph”). This represents how the word was produced by the child. Given that XML files are systematic, this representation holds across all the XML files in the database. If a particular tag is not present, it is simply not extracted and is left blank.

Once the CHILDES data were extracted and placed into a format consistent with the presentation of Djuna's data, four undergraduate students from Indiana University Bloomington assisted in completing additional organizational steps. They supplied phonetic transcriptions of target words where transcriptions were not available and also supplied counts for new words and new utterances in accordance with the parameters described above. When these tasks were complete, the present researcher reviewed all data sets before submitting the data to analysis. The subsections that follow describe the methodology used in each study and lay out the role of each data set in the present research.

6.2 Child: Djuna

6.2.1 Study details and methodology

This subsection presents the methodology employed in a diary study of the developing phonological system of one female monolingual child acquiring American English (Djuna [dʒu.nə]), the daughter of the present researcher who is a trained linguist. Djuna's development is normal. She is cared for in the home by the mother or father most of the time and by a babysitter (whom also is a native English speaker) 4-5 hours per week. During the period data were collected for this research, Djuna had no siblings, and she had no regular exposure to any language other than American English. Bridging the second and third trimester of pregnancy, Djuna's mother participated in an eight-week intensive Turkish course, and when the child was aged 0;9 and 0;10 her mother studied Hungarian. The mother spoke to the child in Hungarian in addition to English during this period and for a short period afterward. It is not believed that this limited exposure to basic Turkish and Hungarian had any significant or lasting effect on Djuna's phonological development.

Data collection began when the child was 12 months old, at the onset of word production, and is ongoing; Djuna is now aged 3;8. This general time period, which differs in age from child to child, is valuable for study because it enables a close look both at the very beginnings of a developing phonological system and also the point at which a phonological system begins to show increasing complexity. The analysis presented for Djuna covers data collected from age 1;0 to 1;4. During this period, the researcher was available to spend several hours at a time per day during most weekdays and during entire weekends with the child, thus being present for the bulk of word production as it occurred.

Sessions for collecting data, then, covered substantial spans of time, which allowed for detailed and thorough data collection, including both phonetic transcription and, where relevant, contextual notes. While contextual notes are not available in rich detail throughout, the additional details available for a given phonetic transcription—made possible by the documentation circumstances here described—provide a nuanced perspective on possible word production strategies. For example, within a span of only a few minutes during the first month of word production, the researcher transcribed six distinct utterances for the target word *giraffe* [dʒɨɹæf], shown in (3):

(3) [ʒa]
[ʒʌwa]
[ʤa]
[ʒʌʒa]
[ʒua]
[ʤia]

This observation is notable because change happens quickly for early acquirers of language. Had these utterances occurred on different days, it would be possible to posit that the child was employing newly acquired phonological elements in attempts to produce *giraffe* each time. Instead, however, it is suggested that she was working at a rapid pace to use the tools she possessed at the time to work on producing *giraffe*, a target word that presents articulatory challenges with its initial affricate [dʒ], medial liquid [ɹ], and final [f], and also its iambic rather than trochaic stress pattern. Distinct templates are observed in this selection of data, serving as confirmation for the presence of these templates in Djuna's phonological toolkit at the time. This phenomenon is discussed in more detail in Chapter 7.

Data were collected in a natural setting (i.e., in the child's home), in the presence of the mother, the present researcher, and frequently also the father. Words that the child produced were documented by way of broad transcription in a notebook at the time of utterance; recording equipment was not used. No word was documented unless the child successfully produced it at least twice in order to help ensure that the child had in fact acquired the word and had not simply articulated it by chance or imitation (as in Macken, 1979). In some cases, multiple utterances were needed in order to confirm transcription details.

Data were collected by way of both elicitation and spontaneous speech. Elicitation was initiated by either of the child's parents asking "What's this?" or "Who is this?" when looking at picture books, photo albums, the television, or objects in the room or outdoors. This method of data collection assists in confirming a connection between a phonetic form and a referent. For words documented by way of the child's spontaneous speech, it is more difficult to establish a clear connection between a phonetic form and its referent. While some subjectivity is involved in making this decision, Djuna very frequently pointed at items or people that were the subjects of her productions, which assisted in legitimizing this connection. Imitations, or repetitions following the speech of either parent were, not documented, with the intent of accessing the developing representational system. This issue is discussed in detail in Chapter 2.

As noted in Chapter 2, there are both benefits and limitations involved with a diary study. One certain benefit results from sessions for documentation doubling as times of caretaking. When the role of parent is concurrent with that of researcher, one benefits from intimate knowledge of a child's behavioral, communicative, and articulatory tendencies. Having ample experience with the child, this researcher is of the opinion that a natural setting without the obtrusion of recording equipment was most conducive to obtaining an optimally rich data set. At the time of the study, Djuna was significantly more talkative in the company of people with whom she was familiar than with strangers. The caretaking situation described above enabled the researcher to obtain not only productions of most, if not all, of the words the child acquired but also to obtain multiple pronunciations in nearly[1] accurate chronology. Data were collected in a variety of situations, such as while the child was playing, eating a meal, or interacting with either of the parents.

One limitation of this study is the lack of recorded material and, thus, the inability to conduct acoustic analysis and to engage in repeated listens in order to confirm

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[1] "Nearly" is used to qualify this description of the accuracy of Djuna's word production chronology because, while the mother was present for much of the day, there were parts of the day when she was not present and, thus, likely missed the first production of a given word or pronunciation. Additionally, because data collection coincided with times of caretaking, there were occasionally times when words were missed since caretaking is higher in priority than data collection.

transcription. Because of this—and because consonants are more easily captured than vowels—consonants are the focus of the analysis. Additionally, vowels at this stage of development vary greatly in their position in the articulatory space; the articulatory qualities of consonants are relatively more stable and conducive to broad phonetic transcription, which was used to document word production. Furthermore, the developing abstract phonological system, rather than acoustic detail, is the focus of this research.

In order to provide a check on the researcher's qualification and proficiency in transcription, a reliability measure was performed. Both the researcher and a trained phonetician provided and compared transcriptions for one recording of one minute and fifty-five second duration. Using the Recorder app on the researcher's iPhone, the recording was made when Djuna was aged 1;10, six months past the end of the investigation period for this study. A later recording was used since recordings were not available from the investigation period. The intention was to demonstrate the researcher's general transcription reliability and not to provide a measure of the reliability of the transcriptions used in the current work. The quality of the recording is somewhat clear but with background noise from the outdoors. The researcher and the trained phonetician independently listened to the recording and transcribed the child's utterances. Afterward, the researcher aligned the transcriptions by segment within tables, as shown in (4):

(4)

Target word	*five*			*six*		*seven*				*eight*	
Researcher	f	aɪ	f	s	ɪː	s	æ	ð	ə̃	eɪ	t^h
Phonetician	f	ay	(f)	h	ɪ	s	ɛ	ð	ĩ	ei	t^h
Agreement	X	X	X		X	X	X	X	X	X	X

The data presented in (4) include a small sample from the transcribed recording. Transcription agreement is indicated by an "X" at the bottom of the segment column in question. Agreement here indicates that the transcribed segments are deemed "sufficiently close", even if they are not identical to one another: some differences in transcription of vowel quality, for instance, might be so great that agreement would not be warranted. If a specific vowel was marked by one transcriber as [i] and by the other transcriber as [a], these two transcriptions should not be considered to agree. A difference between [æ] and [ɛ], meanwhile—as occurs in (4), in the transcription of the word *seven*—is less severe, particularly given the child's developing vowel space. As such, these transcriptions are considered to be in agreement even though they are not identical. Transcriptions deemed "allowable" herein are of the following type: they consist of vowels that were transcribed differently but are in relative proximity within the vowel space. Transcribed units differing in this way are deemed to be functionally equivalent. Consonants differing by voicing quality were considered to be in agreement. This feature was not studied in the present research because, in the early stages of phonological acquisition, children have not yet acquired voicing distinction. Thus, the difference in voicing between [p] and [b], for example, is not relevant for these purposes. Transcribed units differing by place of articulation, in contrast, were not considered to agree. The current work uses broad transcription, so transcriptional inconsistency attributed to the difference between broad and narrow transcription is ignored. Differences between diacritics for aspiration or nasalization, for example, do not factor into the calculation. Using this metric, then, the researcher and phonetician transcribed 10 of 11 segments in (4) either exactly alike or sufficiently close as to be deemed "in agreement", and the transcription of 1 segment differed. The entire transcription sample was composed of 71 total segments, with 83% intertranscriber agreement. This percentage may have been higher in the absence of background noise in the recording, but it is, nevertheless, acceptable in view of the ranges reported in the literature (Gooch et al., 2001; Oller & Ramsdell, 2006). According to Louko and Edwards (2001), anything greater than 75% is acceptable, and for the speech of children, Stoel-Gammon (2001) concluded that transcription agreement between 60% and 80% is acceptable.

6.2.2 Overview of the child's phonological development

Djuna produced her first word at age 1;0, a developmental point which is about average Clark, 1993; de Villiers & de Villiers, 1978; Dromi, 1987; Gerken, 2008; Tomasello, 2003). From there, she progressed with relative rapidity, producing 12 new words during the first month of word production, and by age 1;5 she had acquired 178 words. Djuna's early phonological development is compatible with research on whole-word representation during this period (e.g., Jaeger, 1997; Macken, 1979; Priestly, 1977/2013; Vihman & Croft, 2007). She relied somewhat heavily on five distinct whole-word templates and less heavily on a sixth template. Syllabic templates are not the focus of the present research, but she also exhibited reliance on particular syllable patterns at different points in time.

6.2.3 Role of the child's data in the present research

Djuna's data are exemplary for illustrating the emergence and later abandonment of templates in connection with changes in lexicon size (Vihman & Vihman, 2011), and later for illustrating the merging of templatic patterns in an increasingly complex phonological system (Macken, 1979). The data also serve as a clear starting point for the creation of a schematic model representing variable degrees of abstraction as new and established patterns interact (Langacker, 1987; Taylor, 2002). Furthermore, because utterances were documented to reflect the sequence in which they were produced, the data lend themselves to interpretation using the concepts of dynamic systems theory (Thelen & Smith, 1994). In this research, Djuna's developing phonological system sets a foundation both for templatic analysis and schematic modeling. The developing phonological systems of the other children whose data are involved in this research function to illustrate points of interest where system behavior bears similarity or diverges, in exposition of both templatic and schematic structures.

6.3 Child: Charlotte

6.3.1 Study details and methodology

This subsection describes the study from which data for the child Charlotte were collected. Data were collected from Charlotte as part of a large, longitudinal study conducted between 2003 and 2005, the purpose of which was to trace the path of early normal speech development from the onset of canonical babbling through age 3;6. The twenty-one children included in the study were located by informal referral. The researchers collected data using video and audio recordings, which took place in the children's homes, followed by transcription. Recordings were made during natural interactions between the parents and child, and sometimes with the researcher if the condition was deemed fit. This research was led by Barbara L. Davis (see Davis & MacNeilage, 1995; Davis et al., 2002).

Charlotte's data were selected for inclusion in the present research because an abundance of data available during the relevant developmental period are available on CHILDES. Data were collected from age 0;10.12, at the onset of canonical babbling, to age 2;11.22. Charlotte, born 10/29/2002, is a female learner of American English with one sibling; while it is not stated explicitly, it is assumed that Charlotte is monolingual. Her development was judged to be normal by way of a parent case history report, a hearing screening, and the Battelle Developmental Screening Inventory (Guidubaldi, Newborg, Stock, Svinicki, & Wneck, 1984).

6.3.2 Overview of the child's phonological development

Data were collected from the time Charlotte was aged 0;10, but first words do not appear until she is age 1;1. No data appear in the database from age 1;1.19 to 1;3.1. It is not clear from the information available on the CHILDES web site whether this gap is due to an absence of recording sessions by the researchers or a period of relative quiet after the initiation of word production. Data to be used in the present research cover age 1;1 – 1;8. The difference in the range of age covered between Djuna and Charlotte is due to differences in the development of lexicon size and in patterns of template use. Because Djuna's lexicon size increased rapidly, a shorter range of data is able to provide sufficient material to substantiate analysis. However, because Charlotte's lexicon size increased more slowly, a longer age range is required to reach a point at which analysis of templatic behavior is possible and schematic representation is informative.

By age 1;3 (4 months into word production), Djuna's production began to exhibit more complex phonological patterns that enable informative templatic and schematic analysis. In Charlotte's data, however, it is at about age 1;5 (6 months into word production) that notable changes in template use are first observed, and again at age 1;7. These points in time are judged to be informative for an intricate understanding of Charlotte's developing phonological system, so a longer range of data is included for analysis than that for Djuna.

6.3.3 Role of the child's data in the present research

Charlotte's data are used in the present research to highlight differences in templatic patterns observed in children and variable patterns of template use in connection with other templates and with changes in lexicon size. Initially, the gap in the data between age 1;1 and 1;3, at a point of crucial development—put the data at risk of possible exclusion. However, two points are worthy of consideration: (1) Charlotte had uttered only two new words in two distinct sessions during the first month of word production, so it was not the case that she had acquired a rich production vocabulary and then stopped, but rather that she had produced a couple of words, followed by a short gap in production; and (2) upon analysis of the data, it became clear that Charlotte exhibits interesting reliance on templatic patterns in her early word production, which illustrate strategies that contrast with those of the other subjects involved with this research. In consideration of these points, the data were judged valuable for illustrating important nuances in phonological development, which can be uniquely captured in templatic analysis and, thus, rendered in schematic analysis.

6.4 Child: Trevor

6.4.1 Study details and methodology

This subsection provides details of the study during which data were collected from the child Trevor. These data are taken from a larger study undertaken by a team of researchers led by A.J. Compton throughout the 1970s, the purpose of which was to achieve as a precise a mapping of phonological development as possible using data from several children. Data were collected by way of a diary study for each of four children studied. Full details of the study's methodology along with analyses of onsets, multi-word utterances, and phonological features are found in Compton and Streeter (1977); Pater (1997) offers an optimality theoretic perspective on what at the time had been previously unpublished data. Data for each of the children included in the study are now included in the PhonBank section of the CHILDES database (MacWhinney, 2000; Rose & MacWhinney, 2014).

Trevor, born in December of 1971, is a male monolingual child learning American English (as spoken in California) at the time of the study, who exhibited normal development. It is unknown whether or not he had any siblings or was exposed to other languages. Data collection began when Trevor was aged 0;8, during the babbling period, and continued through the age of 3;1.08. The researchers provided instructions to the parents for documenting phonetic detail in word production, and ensured that each child was in a comfortable environment (i.e., with the parents doing regular daily activities). Before the study began, the parents—who are speech pathologists—received additional training in the phonetic transcription of child speech. Data were collected in notebooks on at least four days per week, covering at least four hours per day by both parents. Periodically one of the researchers visited the home to cross-check transcriptions with the parents, and later when the children were producing words more frequently tape recordings were made and reliability checks were again conducted.

6.4.2 Overview of the child's phonological development

The documentation sessions available for Trevor on CHILDES are particularly valuable because they allow a view into the babbling period as Trevor transitions into word production. He produced his first word early relative to the average, at age 0;8, but progressed slowly until age 0;11, by which time he had produced 11 new words. From this point, his lexicon size increased steadily and more quickly each month, excluding a drop in the production of new words documented at age 1;2.

Data for Trevor to be included are from age 0;8 – 1;3. As noted, and similar to Charlotte, Trevor's lexicon size was too small during the first three months when word production was documented to result in informative analysis. Thus, also similar to Charlotte, data covering 8 months of word production—in contrast with 5 months for Djuna, is used in this research. Unlike Djuna and Charlotte, template use is not observed in Trevor's data at the onset of word production, but rather not until age 0;11, his fourth month of word production. This difference offers an insightful developmental contrast. Additionally, overall Trevor relies much less on templates to facilitate word production, as indicated by a much lower proportion of template use relative to total utterances per month, than Djuna and Charlotte (comparative data figures for all four children are provided in Chapter 7). These measurable differences contribute an informative perspective to understanding the relationship between phonological development and template use, discussed in detail in Chapter 7.

6.4.3 Role of the child's data in the present research

Trevor's data, like that for Charlotte, is used to highlight differences in templatic patterns between children and also different patterns of template use in connection with other templates and with changes in lexicon size. Since the data available for Trevor follows a consistent path, with no gap in time, it exhibits additional individual variation in the unfolding of schematic structure in early phonological development. The data offer support for the utility of the schematic model by showing that schematic representation, particularly as it is interpreted through dynamic systems theory, is notably suitable for highlighting differences in developmental paths across children. A schematic model of specific prominent patterns in Trevor's early phonological development is used to exhibit how detailed phonological variation within a given child's data contributes to a more accurate mapping of phonological development as patterns of varying stability interact.

6.5 Child: E

6.5.1 Study details and methodology

This subsection provides details of the study of the child E (Inkelas & Rose, 2003; 2008). These data, collected in a longitudinal corpus available in the PhonBank section of the CHILDES web site, derive from a diary study conducted by the parents of the child, both trained phonologists, between 1997 and 2001. Data were collected primarily by the mother and to a small extent by the father, as often as possible in a natural setting during regular family activities.

The child, born December 22, 1997, is a male monolingual learner of English with normal development. He had no significant exposure to other languages during the time of the study. The mother is a native speaker of American English, and the father is a native speaker of Turkish, with native proficiency in American English. Only English was spoken in the home. E has one brother who is two years and five months older.

Data collection began when E was aged 0;6.9 and continued until age 3;9.29, using phonetic transcription; no video or audio recordings were employed in documentation sessions. The mother describes E's phonological developmental peak to be between ages 0;6.9 and 2;9.9.

6.5.2 Overview of the child's phonological development

E's first word was located in the database during a session in which E was aged 0;8. During this month, 6 new words were produced. Like Charlotte and Trevor, in contrast with Djuna, E's rate of word production increased slowly but steadily at first. For the first five months of word production, the number of words oscillated between 2 and 6 new words per month. Over the following three months, covering age 1;2 through 1;4, E's word production increased slightly, and at age 1;5 word production began to increase more rapidly, with the production of 51 new words when E was aged 1;7.

Unlike Djuna and Charlotte, but like Trevor, E's first instance of observed template use did not occur at the onset of word production but rather during the second month of word production, when E was aged 0;9. E's data show reliance on a number of templates and, as is the case with the other subjects in this research, exhibit changes in template use. Yet more interesting is his prominent use of multiple templates to produce an individual utterance. For example, at age 0;11.5, E produced [hæːɪ] for *hi*, employing both a LOW-HIGH VOWEL template and an H-INITIAL template, present elsewhere in the data. Analysis of data for the selected period shows that E uses multiple templates to produce an individual utterance with remarkable consistency compared to the other subjects—in nearly 29% of all utterances on average. The next closest value is in data for Djuna, who uses multiple templates to produce an individual utterance in just over 4% of utterances on average. This observation reveals a sharp point of contrast between E and the other subjects included in this research, which is particularly informative for looking to individual differences to understand the behavior of templates and the formation of schematic structures, discussed in more detail in Chapter 8.

6.5.3 Role of the child's data in the present research

Because E's data exhibit unique patterns of templatic use relative to the other subjects included in this research, it offers an informative point of contrast in templatic analysis and can usefully depict schematic analysis. What can differ from child to child are the specific phonological units and strategies that a given child uses to begin producing words and the subsequent path that each child takes as the phonological system becomes more complex. This is precisely what the schematic modeling at the center of this research aims to illustrate. Despite including a much lower percentage of multi-template utterances than E's, Djuna's data illustrate the utility of the schematic model remarkably well. Within the first three months of word production, multiple templates were used to produce individual words. While this phenomenon nearly disappeared for a few months, around age 1;3, a different set of templates began to mingle, coincident with a lexicon containing many more words and a much more complex phonological system (i.e., a greater number of sounds and sound patterns in use).

The schematic rendering of early phonological data is valuable for its ability to show this process in continuous time. While Djuna's data provide a baseline example of schematic structure in motion, E's data are used to show what a developing phonological system looks like when multiple patterns are used in conjunction with notable frequency in the early stages of word production. Charlotte's and Trevor's data, with a fairly low percentage of multi-template utterances, are used as points of contrast for how Djuna's and E's data take shape in schematic structuring.

6.6 Connecting data with theory

The initial diary study of Djuna's phonological development, which prompted this research, was undertaken with the simple goal of finding out whether templatic behavior would be seen, and templates were readily observed. The data sets located on CHILDES were selected because they offer data from the target developmental period rich enough in detail for the intended analysis. These data were selected with no certainty about whether templates could be found. As readily as in Djuna's data, templates were identified, and they were identified with differences in quantity, quality, and proportion to utterances that do not use templates. These observations, discussed in detail in Chapter 7, reveal important characteristics of early phonological development.

Moreover, these sometimes coincident and sometimes divergent patterns across children lend themselves readily to schematic structuring. Submitting distinct and detailed data sets to schematic analysis reveals markedly different paths of phonological development in close focus such that nuanced conclusions can begin to be drawn about evolving representation in early development. Interpretation of the data within dynamic systems theory provides the vocabulary with which to clearly describe the processes involved in this challenging early period of acquisition.

Chapter 7: Data and templatic analysis

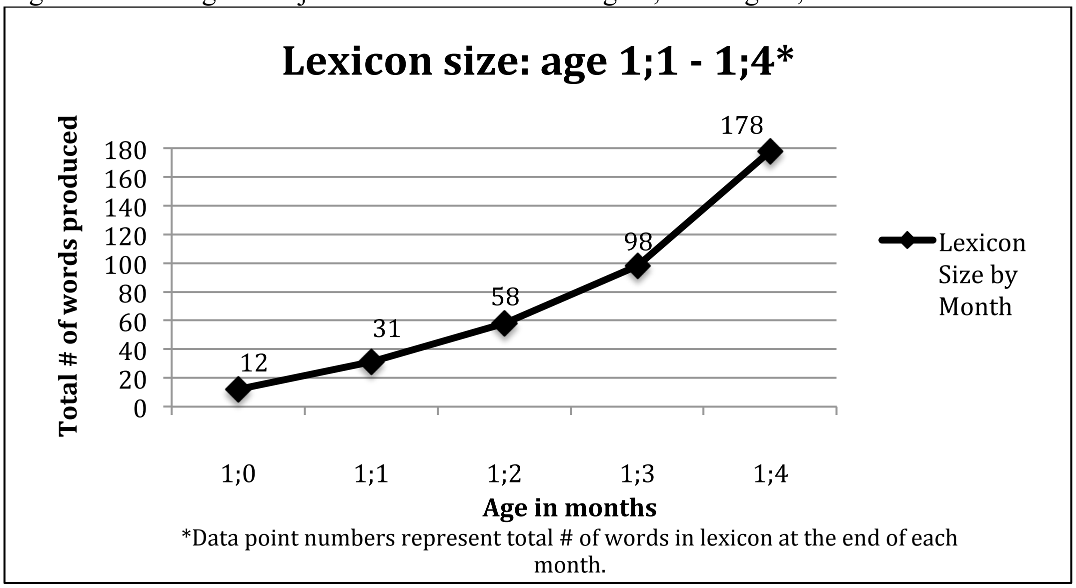
7.1 Introduction

This chapter offers a detailed templatic analysis of data collected for Djuna, Charlotte, Trevor, and E. As described in Chapter 6, data for Djuna are presented as the center of this research, with which analyses of the other three children (Charlotte, Trevor, E) are set in contrast. Section 7.2 provides data and a thorough analysis of Djuna's data, and Section 7.3 attends to data for Charlotte, Trevor, and E in context with that for Djuna. Analysis suggests that Djuna was working with a limited set of phonological units to produce her first words. As a consequence of the routinization of phonological patterns based in these units, her early utterances share similar phonetic shapes. A close look at the data reveals the processes by which a production pattern becomes an articulatory routine. A comparison of trends across all four children appears at the end of the chapter, offering a rich perspective on templatic behavior.

7.2 Overview of the data: Djuna

Djuna began producing words at about age 1;0, which is representative of typical development (Clark, 1993; de Villiers & de Villiers, 1978; Dromi, 1987; Gerken, 2008; Tomasello, 2003). During the first month of word production, she produced 12 distinct words and 28 distinct utterances. While she initiated word production at a typical developmental age, she added new words to her lexicon at a relatively rapid pace and continued to do so throughout the course of the period reported in this study, increasing her lexicon size to 178 words by the time she reached age 1;5. Changes in Djuna's lexicon size from age 1;0 through 1;4 are shown in Figure 7.1. This measure is used in coordination with examples from the data to illustrate characteristics of template use.

Figure 7.1. Changes in Djuna's lexicon size from age 1;0 through 1;4.



An utterance is counted as distinct the first time it is produced for a given word; sometimes this results in homonymous forms for variant pronunciations across words, especially early in development when phonological knowledge is limited. Table 7.1 displays a chronological list of utterances produced during the first month of word production. While exact homonyms do not appear in this list, near-homonyms were documented in utterances for *pop* [pa] and *bubble* [ba]. Exact homonyms were observed in the following month, with the acquisition of new words while the phonological system was still limited. For example, Djuna produced [kæ] for both *cat* and *glasses*, in which she employs the target-appropriate initial consonant followed by the vowel in *cat* and stressed vowel in *glasses*. Children commonly reduce consonant clusters at this stage, often omitting the more sonorous consonant (McLeod et al., 2001; Ohala, 1999). In this case, the initial cluster [gl] in *glasses* was reduced to [g]. This is one of a host of processes that result in homonymous forms in early child speech. In this research, each time a new form was produced for a given referent it was counted as an utterance, even if the form was identical to a form produced for another referent.

Table 7.1 Consecutive list of words Djuna produced at age 1;0, including variant pronunciations (numbered as utterances).

Word #	**Utterance #**	**Target word**	**Child phonetic form**	**Template**
1	1	*butt-time*[1]	[bʌttʰam]	HIGH-LOW V
	2	*butt-time*	[bʌta]	HIGH-LOW V
	3	*butt-time*	[bʌtap]	HIGH-LOW V
2	4	*peek-a-boo*	[pi:bu:]	CONS HARM
	5	*peek*	[bɪka]	LAB-VEL; HIGH-LOW V
	6	*peek*	[pɪka]	LAB-VEL; HIGH-LOW V
	7	*peek*	[pɪk]	LAB-VEL
3	8	*pop*	[pa]	
4	9	*bubble*	[ba]	
	10	*bubble*	[bʌku]	LAB-VEL
5	11	*Blackhawks*	[bʌk]	LAB-VEL
	12	*Blackhawks*	[bʌkʰa]	LAB-VEL; HIGH-LOW V
	13	*Blackhawks*	[bɛkʰa]	LAB-VEL; HIGH-LOW V
	14	*Blackhawks*	[bæ]	
	15	*Blackhawks*	[bæk]	LAB-VEL
6	16	*daddy*	[dætʰ]	CONS HARM
7	17	*button*	[bʌ]	
8	18	*giraffe*	[ʒa]	
	19	*giraffe*	[ʒʌwa]	HIGH-LOW V
	20	*giraffe*	[dʒa]	
	21	*giraffe*	[ʒʌʒa]	HIGH-LOW V; CONS HARM
	22	*giraffe*	[ʒua]	HIGH-LOW V
	23	*giraffe*	[dʒia]	HIGH-LOW V
9	24	*eye*	[æ]	
10	25	*Djuna*	[dʒua]	HIGH-LOW V
11	26	*nose*	[zia]	HIGH-LOW V
	27	*nose*	[ʦia]	HIGH-LOW V
12	28	*glasses*	[gæ]	

[1] *Butt-time* is a word that Djuna heard during her bath time. When it was time for her to stand up to get her bottom washed, her parents sang the theme song for Batman and instead of *Batman* said *butt-time*. Djuna began saying *butt-time* on cue early in her word production.

With a complete list of words and utterances during the first month of production, Table 7.1 offers a view of the way words and newly initiated utterances were documented, and reveals the emergence of early phonological patterns. For example, a clear pattern of [b]-initial utterances emerges. While a preference for an initial consonant does not exhibit templatic behavior, it nevertheless sets the stage for subsequent phonological development in terms of templates viewed within a dynamic system. Conceptualized in terms of dynamic systems theory, the property of self-organization—by which the component parts of a system may spontaneously form patterns of new behavior (Kelso, 1997)—can help explain the emergence of the labial-velar pattern seen in utterances 5-15 out of the labial-initial utterances that comprise the first words.

The attraction to [b]-initial words and Djuna's successful attempts at producing their onsets is not in itself surprising since labial stops, common in the world's languages, tend to be acquired earlier than more marked sounds (Locke, 1983). Nevertheless, it is informative to describe the occurrence of labial stops in the context of Djuna's developing consonant inventory. Among utterances produced at age 1;0, [b] occurs in the initial position in 16/28 (57.14%) utterances. All of these are target-appropriate, allowing for variation in the application of voicing. Djuna clearly targets words with an initial labial consonant and, further, seems to rely on these words in the first month of word production. This observation supports the emergence of a templatic pattern—or an attractor, in terms of dynamic systems theory—resulting from the use and re-use of patterns constituting prelinguistic vocal motor schemes (McCune & Vihman, 1987), which facilitate the eventual production of target adult words. During the early period of word production when a child begins to draw acoustic images from associated articulatory gestures, the use of routinized templates helps to simplify the child's task (Vihman, 1993). This observation supports analysis of a developing phonology as a dynamic system such that "[p]atterns of repeated activity over time become stable attractors" and are primed to "generate future activity" (Thelen & Smith, 1994: 180). Language systems are built on patterns of activity, and repeated activity contributes to the generation of the future use of a given pattern. Evidence of this is found in the generation and use of phonological templates in the data presented here and elsewhere.

While babbling data for Djuna are not abundant enough to determine a firm correlation between the pre-linguistic frequency of labials, enough supplementary notes and contextual information are available to point to babbling patterns as a source of at least one of Djuna's first templates. Specifically, a labial-velar pattern was observed in Djuna's pre-linguistic vocalizations such that there was initial uncertainty about whether her first word was *book* [bʊk]. The conclusion was, however, that a connection between the labial-velar sequence and a referent was not clear enough to call it the child's first word. This babbling pattern, nevertheless, likely contributed to the development of the labial-velar template (discussed in detail below).

Another phenomenon is seen in the data displayed in Table 7.1. Starting at the child's eighth word, comprising utterances 18–23, is a sequence of variant pronunciations for *giraffe*. These were documented consecutively before the attempted production of another new word or a new pronunciation of an older word. Contextual notes from the study supplement the data to confirm that these utterances were produced in sequence within a period of a few minutes while the child was playing in her bedroom, which was decorated with giraffes. These utterances are listed in (1):

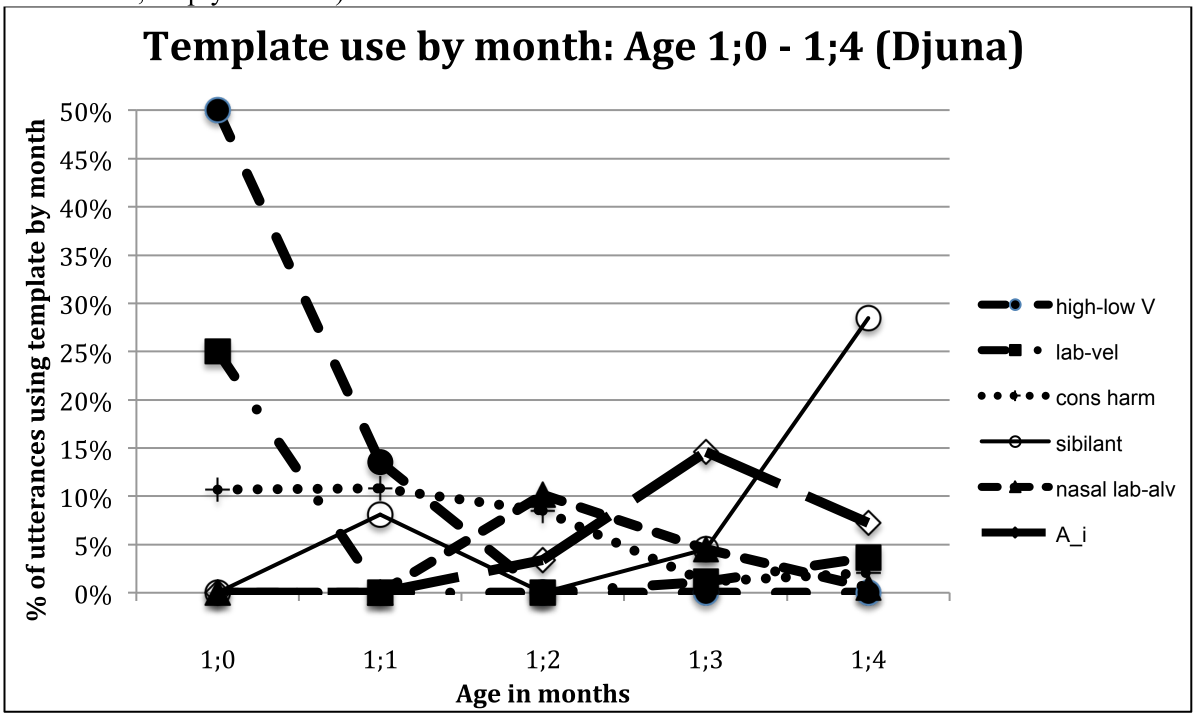
(1) [ʒa]
[ʒʌwa]
[ʤa]
[ʒʌʒa]
[ʒua]
[ʤia]

This sequence serves as a window into the child's production capability and phonological toolkit at the time, revealing multiple phonological patterns as she attempts to produce the word *giraffe*. Two templates (i.e., HIGH-LOW V—in [ʒʌwa, ʒʌʒa, ʒua, ʤia]; CONSONANT HARMONY—in [ʒʌʒa]) to be discussed below, and three syllable patterns (e.g., CV, CVCV, CVV) are seen, all of which are prevalent in data from this period. In this "episode" of production practice, the child seems to be working on producing *giraffe* with the same limited set of sounds and whole-word patterns she is currently using to produce other words. This behavior supports arguments for templatic representation in early phonological development.

7.2.1 Templatic analysis

Six templatic patterns were identified in the data and are represented in charts displayed below; analysis of the four most prominent patterns follows. In order to be classified as a template, a given pattern must be observed in a minimum of 10% of the data sampled (as in Vihman, 2016). Figure 7.2 shows changes in the frequency of template use by the percentage of utterances that use each template in each month under investigation. All six templates are included in the figure: high-low vowel (HIGH-LOW V), labial-velar (LAB-VEL), consonant harmony (CONS HARM), sibilant (SIBILANT), nasal labial-alveolar (NASAL LAB-ALV), and A_i (A_I). All but CONS HARM and NASAL LAB-ALV receive full attention here, although brief commentary on these templates is included.

Figure 7.2 Six templates identified in Djuna's data collected from age 1;0 through 1;4: HIGH-LOW V (dashed line, filled circle), LABIAL-VEL (dashed-dot line, filled square), CONS HARM (dotted line), SIBILANT (thin line, empty circle), NASAL LAB-ALV (short-dashed line, triangle), A_I (long-dashed line, empty diamond).



7.2.1.1 The CONSONANT HARMONY template

The CONS HARM template, which includes all utterances exhibiting long-distance assimilation between consonants,[2] is used with enough frequency during at least some of the months under investigation to receive status as a template, but its pattern of usage is not as prevalent as the others and does not reveal as much about Djuna's development as the other patterns in use. The phenomenon is common in child data and has been thoroughly examined in Vihman (1978) and examined in terms of templatic behavior in Vihman and Vihman (2011). At the stage of development investigated in this research, children typically have not yet acquired voicing distinction, as discussed in Chapter 2, so

[2] Among the data for the other children under investigation in this study, distinction has been made, where relevant, between different kinds of consonant harmony (e.g., nasal, labial, sibilant, alveolar, velar).

laryngeal setting is ignored here in the identification of consonant harmony in child forms. This approach is taken in Vihman and Vihman (2011), with example forms in Table 7.2.

Table 7.2 Child forms counted as accurate where voicing distinction is ignored.

Child form	Target word	Target form
[gʊk]	book	[bʊk]
[pu:m]	spoon	[spu:n]
[mu:n]	spoon	[spu:n]
[tidu]	tigu	[tigu]
[bɪpsi ɪtsi]	itsy bitsy	[ɪtsi bɪtsi]
[tɛdɛ]	tere	[tɛrɛ]

Data from Vihman and Vihman, 2011: 121-123

For example, in the child form for *book* [gʊk] the initial consonant is produced as the velar [g] instead of the target [b], harmonizing with the velar final consonant [k]. In the first child form for *spoon* [pu:m], the target final alveolar nasal [n] is produced as a bilabial nasal [m], harmonizing with the place feature of the initial bilabial stop [p] (acknowledging that [s] was omitted in a cluster reduction process). In the second child form for *spoon* [mu:n], the target bilabial stop [p] is produced as a bilabial nasal [m], subject to a harmony process with the word-final nasal [n]. Consonant harmony can be identified in a child form if long-distance assimilation of place or manner is present, and laryngeal setting can be ignored; the assimilating consonants need not be identical. Vihman (1978: 281) offers two primary motivations for consonant harmony in early child speech: “to provide a source for substitutions of sounds the child cannot pronounce” and “to allow focus on new segments or extra syllables by reducing the overall complexity of the word”. Consonant harmony as a strategy provides the child with a solution for pronouncing a word for which he or she has not yet acquired all of the target sounds. This relieves the child of the burden of producing every sound, some of which he or she may not yet have acquired.

As in Vihman and Vihman (2011), child forms in which consonant harmony is present are included in the tally for this template. Selected use of the template results in forms that are accurate (or fairly accurate) relative to the target. Selected forms are identified among forms using the template because they contribute to a comprehensive view of the child's production strategies, taking into account the generalization of a pattern employed in a selected form to adapted use. The first instance of consonant harmony occurs at age 1;0, the first month of word production, in selected use for the utterances for *peek-a-boo* [pi:bu:] and *daddy* [dætʰ]. In fact, prior to the documentation of meaningful words, Djuna produced the form [dæt] in a variety of situations and continued to do so (without a clear referent) even after the onset of word production. It seems reasonable to suggest the influence of this babbling pattern on at least her early production for *daddy* [dætʰ]. The first adapted use of the template occurs in the same month, with [ʒʌʒa] *giraffe*, in which the medial [ɹ] assimilates to the fricative element in the initial affricate [ʒ] and the final [f] is dropped. Adapted use of the template is seen again at age 1;1 in utterances for *Elmo* [mɔmɔ, mmo:]. Aside from utterances for *eye* and *Elmo*, Djuna had not attempted at this point to produce any other vowel-initial words, and she had not yet produced [l]. It is not surprising, then, that she omitted the initial syllable [ɛl] and reduplicated one she could pronounce, resulting in what appears as consonant harmony between C_1 and C_2 realized as [m]. Similarly, for *giraffe*, Djuna had not yet successfully produced the medial [ɹ] and replaced it with [ʒ]. While this substitution is not the target-appropriate C_1, it is an early estimation of the target C_1, and consonant harmony is used to produce this word whose individual target sounds Djuna had not yet acquired.

While consonant harmony is common in child language, it never becomes prevalent among Djuna's production strategies. Only 3/28 (11%) distinct utterances were documented to use consonant harmony during the first month of word production and 4/36 (11%) distinct utterances at age 1;1. The use of consonant harmony decreases at age 1;2, documented in only 5/59 (8.47%) distinct utterances, and does not again reach 10% of total utterances in any given month. As such, this pattern receives only brief discussion in the context of more prevalent patterns among Djuna's data.

7.2.1.2 The NASAL LAB-ALV template

The NASAL LAB-ALV template, also, is used with enough frequency to warrant classification as a template but plays only a minor role in development—and does so for a shorter period of time. Because of this, it receives brief commentary but is not a major part of the larger analysis. This template is characterized by a nasal labial consonant followed by a nasal alveolar consonant with an intervening vowel; an utterance in which it appears may also contain additional segments. The first utterances documented to use this template appears in Djuna's attempt at *banana*: [mɛna] (adapted use), at age 1;2.[3] During this month, this template was used in 6/59 (10.17%) of utterances, reaching the required percentage. Then at age 1;3, the template was used in only 4/89 (4.49%) of utterances, afterward declining in usage. In the period of time during which the template was used, it seems to have facilitated the production of new words for which Djuna had

[3] One might expect that the first use of a template would select a target word whose sounds match the template (i.e., selected use), and this is a logical expectation. With that in mind, this template could be housed under consonant harmony specified as nasal harmony, in which case selected use is observed first.

not yet acquired the phonological knowledge needed to produce them accurately. For example, her second attempt at *banana* was [mena] (adapted use). The next new word she attempted using the template was *Minnie Mouse*: [mɪnɛ, mɪnɛmə] (selected use), in which she used the template to initiate the production of a word that contained its basic phonological shape. Just before age 1;3, Djuna produced [mɛɲɛ] and [mɛnɛ] for *lemon* (adapted use). As is expected at this stage of development, Djuna still had not mastered liquids. She negotiated production of the [l] by omitting the first syllable of *lemon*, then employed a CVCV pattern to produce the word. While syllable structure is not included as part of the analysis here, Djuna's data show that the CVCV pattern, which many children use with prevalence at this stage, was dominant, occurring in 19% of her utterances at age 1;3. Notably, her utterances for *lemon* closely resemble her utterances for *banana*, a word she seemed to be practicing during this month, with minor differences in vowel production. These differences in vowel production may be attributed to differences in the target forms and also to articulatory inaccuracy as a result of an immature articulatory apparatus. While this template was useful in helping Djuna increase her lexicon size at age 1;2 and 1;3, its utility quickly declined, occurring in only 1/193 (0.52%) utterances at age 1;5. At the same time, the frequency of other patterns increased, namely SIBILANT and A_I, discussed later in this chapter.

7.2.1.3 The HIGH-LOW V template

The HIGH-LOW V template was dominant during the first month of word production (age 1;0). This template is defined by the presence of two sequential vowels, the first categorized as high and the second categorized as low, with the possibility for consonants to precede, follow, or interrupt the sequence. High vowels are defined loosely as any vowel at or above the level of [ɛ] in the front or [ʌ] in the back of the vowel space. The first vowel in the sequence is typically [u], [ɪ], [ʌ], or [i], and the low vowel is always [a]. This high-low classification is motivated by the prevalence of the pattern both in words in which the child's pronunciation matches or closely matches the target form (e.g. *Djuna* [dʒua]) and in words in which the child's pronunciation diverges (e.g., *peek* [bɪka]). Vowels are defined here as high or low relative to each other; this classification is not intended to reflect absolute values within the vowel space. This is deemed a reasonable distinction given the lack of precision in the articulation of vowels at this stage of acquisition. This template may have developed in part because Djuna's name contains the pattern, pointing to a link between perception and production. This issue of a child's name influencing phonological development is discussed in Vihman (1993), where the initial [l] in the name Laurent is demonstrated to likely be one of other possible sources for a prominent [l]-medial pattern in the child's production repertoire.

During the first month of word production (age 1;0) when this pattern emerged, seven different vowels were documented, with two low vowels (i.e., a, æ) occurring frequently in CV-patterned utterances and as the second vowel in disyllabic utterances, shown in (2):

(2) ʌ, a, ɪ, i, u, æ, ɛ

In the course of this month, words of only one or two syllables were produced, resulting in utterances containing either one or two vowels, respectively. Table 7.3 provides a breakdown of the seven distinct vowel sequences produced during this time. Those exhibiting the HIGH-LOW V pattern are marked with an asterisk. The numbers in parentheses indicate the number of utterances in which the pattern occurred; twenty-eight total utterances were documented during the first month of word production. Single-vowel trends in production at this time are included to present a complete picture. Among utterances exhibiting a two-vowel pattern, 14/16 (87.5%) use the HIGH-LOW V pattern, employing six distinct vowels in total (5 distinct V_1: ʌ, ɪ, ɛ, u, i; and 1 V_2: a). While Djuna attempted seven different vowels during this period, she relied heavily on a HIGH-LOW V sequence in the production of new words.

Table 7.3 Word-bound vowel trends at age 1;0, with HIGH-LOW V patterns marked by *.

Double-vowel patterns	**Single-vowel patterns**
ʌ-a (6; 21%)*	ɪ (1; 4%)
i-u (1; 4%)	a (4; 14%)
ɪ-a (2; 7%)*	ʌ (2; 7%)
ʌ-u (1; 4%)	æ (5; 18%)
ɛ-a (1; 4%)*	
u-a (2; 7%)*	
i-a (3; 11%)*	

Table 7.4 displays both selected and adapted use of this template. Among the selected uses of the HIGH-LOW V template are three different utterances for *butt-time*, and four different utterances for *giraffe*.[4] Each of these utterances contains the HIGH-LOW V pattern as it is defined and is target-appropriate. Among adapted uses of this template are two different utterances for *nose* and the three distinct utterances for *Blackhawks* that also appear in Table 7.4 among utterances using the LAB-VEL template. While the target pronunciation for *nose* contains one high diphthongized vowel (i.e., [oʊ]) and no HIGH-LOW V sequence, Djuna nevertheless employs adapted use of the template in her attempt at the word. It is not clear why she extended this template to target *nose* for production.

[4] This does not include additional utterances for *giraffe* that make use of other templates.

The target pronunciation for *Blackhawks* contains a low-low vowel pattern (i.e., [æ-ɑ]), but again the HIGH-LOW V template, which Djuna routinely uses during this period of time, is employed. As early as the first month of word production, some utterances are observed to employ both the LAB-VEL and HIGH-LOW V templates. Interaction between these templates is discussed in Chapter 8.

Table 7.4 Selected and adapted use of the HIGH-LOW V template.

HIGH-LOW V template			
selected		*adapted*	
bʌttʰam bʌta bʌtap	*butt-time* [bʌttʰaɪm]	zia tsia	*nose* [noʊz]
ʒʌwa ʒʌʒa ʒua dʒia	*giraffe* [dʒiɹæf]	bɛkʰa bʌkʰa	*Blackhawks* [blækhɑks]

This template is in heavy use at age 1;0 (14/28 (50%) distinct utterances), and decreases in use in the following month (5/36 (14%) distinct utterances). The utterance cited above for *peek* [bɪka] is additionally interesting because, while its target form is monosyllabic, the child form is disyllabic. It becomes disyllabic when the HIGH-LOW V template is used to facilitate production; this form also uses the LAB-VEL template, discussed in the next sub-section. The HIGH-LOW V template is seen in Djuna's two productions for the target word *nose* ([zia], [ʦia]) at age 1;0, which are difficult if not impossible to account for in a segment-by-segment analysis. The target coda [z] (and an estimation of the target coda as [ʦ]) appears as the onset in each of these utterances, followed by the same high-low vowel pattern. The HIGH-LOW V pattern (and also the syllable pattern CVV) seen in these utterances is present elsewhere in Djuna's developing system at this time (see utterances for *butt-time*, *peek*, *Blackhawks*, *giraffe*, and *Djuna* at age 1;0, for examples of the vowel pattern), and the presence of the target coda in the onset position can be explained by Djuna's avoidance of sonorant onsets elsewhere in her developing system. These facts justify a templatic analysis as a whole-word strategy to facilitate word production in response to a complex of factors, including limited phonological knowledge, an immature articulatory apparatus, and possible influence of the child's name.

With limited phonological tools in her developing system during her first month, Djuna relied heavily on the HIGH-LOW V template, and less so during her second month of word production, as is seen in Figure 7.1. By age 1;2 this template disappeared as others became more prevalent and, perhaps, useful as Djuna began to work with new sounds and patterns, expanding her facility with the phonetic detail in the ambient language.

7.2.1.4 The LAB-VEL template

The other template most dominant at age 1;0 is the LAB-VEL template. This template is defined by the presence of a sequence of a labial consonant followed by a velar consonant, with an intervening vowel and optional additional segments following the velar consonant; all documented instances of this template occur in words that are labial-initial. Notably, the labial consonant is always target-appropriate; when adapted use of the template is employed, it is always the velar consonant that diverges.

Table 7.5 shows both selected and adapted use of the LAB-VEL template. Among those labeled "selected" are three different utterances for the target word *peek* and three different utterances for *Blackhawks* (i.e., the Chicago Blackhawks, a professional ice hockey team). Each of these child forms and the adult target forms contain the LAB-VEL pattern. One utterance listed is characterized by adapted use of the template: [bʌku] for *bubble*. In this utterance the child employed the LAB-VEL template even though the template does not match the consonantal sequence in the target form. Where something resembling the target [b] is expected as the second consonant, the velar [k], which matches the template, is seen.

Table 7.5 Selected and adapted use of the LAB-VEL template.

LABIAL-VELAR template			
selected		*adapted*	
bɪka	*peek* [pik]	bʌku	*bubble* [bʌbḷ]
pɪka			
pɪk			
bʌk	*Blackhawks*		
bʌk^{h}a	[blækhɑks]		
bɛk^{h}a			

The LAB-VEL template follows a course similar to that of the HIGH-LOW V template. It is dominant in the first month of word production and all but disappears by age 1;1. Out of the first 20 utterances during the first month of word production, this template is found in 8 (40%). This is meaningful because, as with the HIGH-LOW V template, despite the size of the lexicon being small at this point, a high percentage of words targeted are compatible—by way of either selected or adapted use—with these two early templates. In fact, among Djuna's first words are notably uncommon ones, like *butt-time*, *Blackhawks*, and her own name. It must be considered that, while something motivated the initial generation of these phonological patterns, perhaps the patterns themselves motivated the selection of words that Djuna subsequently targeted. Of the 8 utterances among the first 20 using the LAB-VEL template, 7 have adult target forms with this pattern, representing selected use of the template. These are repeated in (3):

(3) [bɪka] *peek*
[pɪka]
[pɪk]

[bʌk] *Blackhawks*
[bʌkʰa]
[bɛkʰa]
[bæk]

The only target form that is not shaped by this pattern (i.e., adapted use) is that produced for *bubble* [bʌbɫ̩] in (4):

(4) [bʌku] *bubble*

It is difficult to account for the utterance in (4) by way of a segment-by-segment analysis. The first two segments are accurate, but a velar consonant is found in place of the second target-appropriate labial consonant, and this substitution pattern is not seen elsewhere in the data. A templatic analysis, however, supports an explanation for both how and why a mismatched labial-velar consonant pattern for *bubble* might occur. Djuna produced this utterance during a period of time (i.e., age 1;0) when she had also produced several words whose targets contain the labial-velar pattern. Accurate production of [ɫ] this early in a child's phonological development is not expected because liquids tend to be difficult at this point (Sander, 1972), but there must still be an explanation for why a velar consonant is substituted for the target C_2 [b] when this sort of substitution is not seen anywhere else in the data set and the child is capable of producing [b]. It could be argued in segmental analysis that the dark [ɫ] in *bubble* contains a velar component, which merges with the target stop in the C_2 position, resulting in [k]. Children are often seen to rearrange and merge elements of target words (Jaeger, 1997; Macken, 1979; Vihman & Croft, 2007).

However, it can also be argued that [u] is an estimation of the dark [ɫ], which is syllabic, as would be the vowel. It is not uncommon for a child to substitute a back rounded vowel for [l] until [l] is acquired. Templatic analysis provides a well-motivated argument for the idea that it is the velar component of the [ɫ], paired with the initial [b], that attracts the use of the LAB-VEL pattern, which Djuna employed also for several other target words during the same period.

It is acknowledged that there are few words and few utterances from which to generalize, but the fact that there is motivation from Djuna's phonological repertoire concurrent with her pronunciation for *bubble* substantiates a templatic analysis of this utterance and others during this period. Interestingly, Vihman and Croft (2007: 695) present data illustrating a labial-alveolar template emerging during the 0;8–0;10 range for a monolingual child learning German, and they describe a more general fronting constraint for data collected from a child learning English, which contains labial-alveolar, labial-velar, alveopalatal-velar patterns (2007: 702). Macken (1979: 21) also reports a general front-back pattern in a sequence of consonants, so there is evidence of a kind of whole-word strategy in the early development of other children, too. This trend may be due to the articulatory ease of this sequence early in development before the acquisition of an expanded lexicon requires greater complexity in order to distinguish the phonetic forms for lexical items (MacNeilage et al., 2000).

7.2.1.5 The SIBILANT template

Two remaining templates play a noteworthy role in Djuna's lexical and phonological development. Unlike the HIGH-LOW V and LAB-VEL templates, which emerge nearly at the onset of word production, these patterns are not seen until near the end of the investigation period for this study. The first is the SIBILANT template, and the second is the A_I template (discussed in the following sub-section). These patterns, which are accompanied by greater phonological complexity, emerged during Djuna's third and fourth month of word production (ages 1;2 and 1;3), respectively, and developed through age 1;4 and just into age 1;5. For perspective, in contrast with the 12 words produced at age 1;0, Djuna had acquired 250 words by the time she reached age 1;5, resulting in many more words whose phonological patterns were more complex.

The sibilant structure that emerges in Djuna's phonological repertoire is initially seen as early as age 1;1, in a pattern involving an optional consonant followed by a vowel and a sibilant sound realized as [ʃ], [s], or either of the affricates [ʧ] or [ʦ]: (C)V<sib>. Waterson (1971) describes a similar sibilant structure produced by the author's eldest child, P, in addition to labial, continuant, stop, and nasal structures. The sibilant structure is characterized by a monosyllabic, sibilant-final pattern, even where the target form does not contain a final sibilant; examples are shown in (5):

(5)		fish	fetch	vest	brush	dish
	1;6	[ɪʃ/ʊʃ]	[ɪʃ]	[ʊʃ]	[byʃ]	[dɪʃ]

(Data from Waterson, 1971: 185)

Table 7.6 shows the utterances in which this pattern appears among Djuna's data, given chronologically and categorized by the specific sibilant segment used in each utterance. The sibilant structure began to emerge at age 1;1, occurring in 3/37 utterances (8.11%), and is next seen at age 1;3, but in only 4/89 utterances (4.49%). It becomes much more prevalent at age 1;4 (55/193 utterances; 28.50%), followed by a decrease in use at age 1;5 (7/139 utterances; 5.04%). While age 1;5 is not included in the current investigation, the numbers are given for this template in order to illustrate the scope of its use. During the time when increased use of the sibilant template was observed, the child was learning facial features (e.g., eyes, nose, ears), many of which are sibilant-final, and was also beginning to use the plural morpheme. What is notable about the sibilant-final template is that its usage begins to increase at age 1;3, when the A_ɪ template reaches its peak, and then markedly increases in usage at age 1;4.

Table 7.6 Three sibilant-structure patterns, sorted by the month in which the utterance was first produced. No representative utterances occur during Djuna's fourteenth month (age 1;2).

Age	Pattern			
	(C)Vʃ	**(C)Vs**	**(C)Vʧ**	**(C)Vʦ**
1;1				[pɪʦ] *picture*
	[ʧʊʃ] *Cheerios*			
	[ʧʊs] *Cheerios*			
1;3		[ge:s] *grapes*	[ʧiʧ] *cheek*	
			[tiʧ] *teeth*	
1;4	[ʤæʃ] *giraffe*	[ʤæs] *giraffe*	[ʤæʧ] *giraffe*	
	[bæʃ] *box*	[bas] *box*	[bæʧ] *box*	
	[piʃ] *octopus* [pɪʃ]	[nos] *nose* [nas]	[gʷæʧ] *grouch*	
	[pɪʃ] *peas* [peɪʃ]	[as:] *elephant*	[pæʧ] *puffs*	
	[bʌʃ] *brush*	[pas:] *puffs*	[mæʧ] *mouse* [maɪʧ]	
	[maɪʃ] *mouse*	[bes] *Bears*	[pɪʧ] *octopus*	
	[gaʊʃ] *grouch*	[mɛs] *mouse*	[biʧ] *Bears*	
	[eʃ] *elephant*	[bɛs] *eyebrow*		
	[biʃ] *Bears*	[ʧis] *cheek*		
		[nes] *nails*		
		[i:s] *ear*		
		[gas] *glasses*		
		[maɪs] *mouth*		
		[pɛ:s] *pants*		
		[dis] *downstairs*		
1;5	[buʃ] *baba ganoush*	[mæs] *Max*	[kaʧ] *squash*	
	[kaʃ] *squash* [gaʃ]	[tys] *toast*		
		[mas] *microwave*		

Contextual details from the diary study during this period reveal that the use of sibilant-final utterances was overwhelmingly prevalent and surfaced around the time Djuna was (1) learning sibilant-final facial features, some of which are plural (*eyes*, *ears*) and some of which are not (e.g., *nose*), in addition to facial features whose target pronunciations are not sibilant-final (e.g., *mouth*, *eyebrow*); and (2) learning to use the plural form in general, unrelated to facial features. While sibilant-final utterances are expected in the instances in (1) and (2)—and additionally for non-plural sibilant-final targets—Djuna also began producing sibilant-final new words whose targets did not have a final sibilant (e.g., *elephant*, *microwave*). Menn and Matthei (1992) describe a similar scenario, wherein utterances produced by the child Daniel came to be produced with a final [s] or [z] even when not target-appropriate. During this rich period of template use at age 1;4, Djuna produced 80 new words (193 new utterances), and the SIBILANT and A_I templates are seen to merge into more complex patterns; a discussion of the A_I template follows.

7.2.1.6 The A_I template

The A_I template is a schematic vowel pattern that first emerged at age 1;2 as the vowel [æ] followed by [i], with the possibility of an intervening consonant and an optional initial consonant. Utterances using the pattern began to fall into three categories: one in which a sibilant occurs intervocalically (æ<sib>i), one in which no consonant intervenes (æ<ø>i), and one with an intervocalic stop (æ<stop>i). As is seen in a more complex schematic figure in Chapter 8, the sibilant and stop categories can be broken down into subcategories specifying the sibilant or the stop consonant. In some utterances, instead of [æ], the vowel in this position was produced further back in the vowel space, as [ɑ] or [a]. The capital A is, thus, used to represent the first vowel in this template.

Table 7.7 presents the utterances in which the A_I pattern occurs, given chronologically. This pattern on its own is interesting in so far as it illustrates Djuna's seeming reliance on a specified vowel sequence used for the production of a number of words during the period between age 1;2 and 1;6. The pattern is appropriate for some targets (e.g., *froggy* [fɹɑgi], *Daddy* [dædi], *Abby* [æbi]), but less appropriate for others (e.g., *lion* [lɑɪən], *elephant* [ɛləfənt], *Blackhawks* [blækhɑks]). At age 1;4, this pattern began to interact with the sibilant pattern, with the sibilant variants occurring between the template-specified vowels; later, this merged pattern began to occur with a final [s]. At age 1;5, other consonants began to be observed between the two vowels. Table 7.8 displays utterances exhibiting the interaction of the A_I and SIBILANT patterns, given chronologically.

Table 7.7 Utterances exemplifying three manifestations of the A_I pattern, sorted by the month in which each utterance was first produced.

Age	**Pattern**		
	æ<sib>i	**æ<ø>i**	**æ<stop>i**
1;2		[næɪ] *lion*	
1;3		[dæi] *Daddy*	[dædi] *Daddy*
			[pæpi] *Abby* [dæbi] [jæbi]
			[dæbi] *apple*
			[dæbi] *diaper*
1;4	[æʃi] *elephant* [æʧi]		[tædi] *Telly*
			[pækʰi] *Blackhawks*
			[mæki] *monkey* [mægi]
			[ʃægi] *froggy*
1;5	[tæʧi] *cracker*		[tæki] *cracker*
			[mæki] *microwave*
1;6	[mæʧi] *Muppets*		[æbi] *Abby*

Table 7.8 shows a representative selection of three categories of utterances: (1) those using a merged A_I and SIBILANT template, (2) those using the merged template with a final [s], and (3) variations on the A_I template merged with the SIBILANT template and final [s]. An example of an utterance representing the A_I and the SIBILANT templates merged is *elephant*: [æʃi] and [æʧi]. This example provides a clear-cut illustration of the A_I sequence and Djuna's routinized sibilant pattern. Again, it is difficult, if not impossible, to account for the phonetic composition of these utterance if trying to trace a path from an adult-like underlying representation of *elephant* [ɛləfənt] to the child utterances. There is little resemblance between the child forms and the target. Repeated utterances in connection with either stuffed elephants or pictures of elephants confirmed that these utterances were being used to refer to elephants. Interestingly, a comparable progression in template and utterance development is observed for the child Alice (Vihman et al., 1994) in utterances coincidentally also targeting *elephant*, in (6):

(6)	age 1;1	[ʔe:, ʔaɪ, ʔɛni]
	age 1;4	[ʔaɪnjə, ʔaijʌ, ʔæ̃ijɨ]

(Data from Vihman et al., 1994: 281-282)

In these utterances, Alice approaches a phonologically challenging word (i.e., *elephant*) using routines that had been facilitating production. Early on she attempted the word with CV ([ʔe:, ʔaɪ) and CVCV (ʔɛni]) forms based on early articulatory routines, as did Djuna, whose first attempt was the entirely unpredictable [dʲɛjɛ] at age 1;2, followed by [eʃ, as:] at age 1;4, employing the sibilant template, and later that month [aʃi, atʃi], initiating use of the merged template, before she more regularly began producing [æʃi] and [æʧi] with slight variation in the initial vowel at age 1;5.

Table 7.8 Utterances exemplifying a merged SIBILANT and A_I template, sorted by the month in which they were first produced. The æ<sib>i column from Table 5 (above) is repeated in the first data column; also included is a list of utterances using the A_I template with a final [s].

Age	**Pattern**		
	æ<sib>i	æ<sib>is	Other related realizations
1;4	[æʃi] *elephant* [æʧi]		
1;5	[tæʧi] *cracker*	[mæʧis] *Muppets*	[oʃis] *lotion*
		[kæʧis] *glasses* [gæʧis]	[b^{ɹ}ɛtis] *breakfast*
			[mækis] *microwave*
1;6	[mæʧi] *Muppets*		
		[æʃis] *elephant* [æʧis]	

Concerning how Djuna may have reached the utterances she produced for *elephant*, a walk through the target form in relationship to the child form—with the child's current phonological system on the whole in view—is informative. Since a child's production of vowels varies within the vowel space at this stage, it is impertinent to spend much time on the initial vowel substitution (i.e., [æ] for [ɛ]), but the initial vowel may have attracted the use of the A_I template, in that the child with yet unstable vowel production employed this previously established whole-word pattern. From a rule-based perspective, it might be posited that the child simply deletes [l] (or the [l]-onset syllable), following the initial vowel, as she does in other words (recall utterances for *Blackhawks* [pæk^{h}i] and *Elmo* [mɔmɔ, mmo:]). In these words, though, [l] is clustered with another consonant. This is not the case in 'elephant', so the pattern is not consistent. A close look at how the child negotiated the medial-[f], however, is especially interesting. While the argument made here is that early child forms cannot be effectively reduced to rules between child and adult target forms, statements akin to what might be conceived as rules can nevertheless play a role in development concurrent with a dominant templatic representation. For example, it is possible that the perceived frication in the target [f] attracted the use of the SIBILANT template, which may contain sibilant fricatives. For several weeks following this period, the child produced [ʃægi] for the target *froggy* [fɹɑgi], and the substitution of a sibilant for [f] was common in other words. At age 1;4, attempts at *puffs* [pʌfs] included [pæʧ, pʌʦ, pʌʧ, pas:], attempts at *giraffe* [dʒɨɹæf] included [ʤæʧ, ʤæʃ, ʤæs], and attempts at *elephant* included [eʃ, as:, aʃi, aʧi], with sibilants substituted for the target-appropriate [f]. Possibly the sibilant template grew out of the somewhat regular substitution of a sibilant for [f]. Priestly (1977/2013) reports a [j]-medial template likely having grown out of a simple substitution process. To finish walking through the child-target forms, in place of the target [ənt] as the final syllable's rhyme, [i] is produced (as in [æʃi, æʧi]), completing the A_I template that occurs in both selected and adapted use during this period of development. Djuna's utterances for *elephant* [ɛləfənt] are highly suggestive of templatic behavior.

Among utterances representative of the merged A_I and SIBILANT templates with a final [s] are *Muppets* [mæʧis], *glasses* [kæʧis, gæʧis], and *elephant* [æʧis, æʃis]. Utterances for *Muppets* and *elephant* represent adapted use of each of the templates. Djuna accurately produces the initial [m] and final [s] in *Muppets*, for example, but employs the templates in order to fill out the rest of the word. She is capable of producing the target-appropriate sounds. For example, she accurately articulates [ʌ] in her utterances for *brush* [bʌʃ], and she accurately articulates [p] in *Blackhawks* [pækʰi] at age 1;4 two months earlier. These target segments are lost in Djuna's holistic approach to producing *Muppets*, however, in which she attends to accurately articulating the initial and final sounds and calls upon a routinized set of sounds for the rest.

Utterances for *glasses* [kæʧis, gæʧis] represent selected use of the merged template, documented at age 1;6. The initial segment is fairly accurate if voicing is discounted, and omission of [l] is admitted as typical at this age. A chronology of utterances for *glasses* can be seen in Table 7.9:

Table 7.9 Chronology of variant utterances for glasses.

Age	**Child form**
1;0	gæ
1;1	kæ
1;1	k^{h}a
1;4	gas
1;4	gaʧə
1;6	kæʧis
1;6	gæʧis

At the end of her first month of word production, Djuna produced [gæ] for *glasses* and at the beginning of the following month, she produced [kæ]. Later that month (age 1;1) she produced [k^{h}a] and [gas] at age 1;4. Near the end of that month (age 1;4), she produced [gatʃə]. Tracing the utterances of this single word, it can be observed that as Djuna learns and adds whole-word patterns to her phonological repertoire she improves—or at least complicates—her attempts at producing *glasses*. In the first month of word production, the utterance uses a CV pattern, articulatorily the simplest syllable (MacNeilage & Davis, 1990), which consists of a target-appropriate initial consonant and vowel (i.e., [gæ], then [kæ]). Three months later, new patterns having been acquired—specifically the final [s]—she produced [gas], which is closer to the target pronunciation. Later that same month, she produced [gatʃə], abandoning the target-appropriate final [s] in favor of the merged A_I and SIBILANT templates that she had begun to use during this period. Finally at age 1;6, she produced [kæʧis, gæʧis]. By way of utterances for this one word, the dynamic evolution of templatic behavior can be observed: simpler templates as attractors surface first in temporary systematicity; then a merged pattern builds on the system's earlier patterns, self-organizing into more phonologically complex patterns as the system becomes more sophisticated. In this way, the tools of dynamic systems theory can clearly conceptualize the continuous processes by which a system develops. This point is one rigorously pursued in this study and is taken up in greater detail in the context of schematic analysis. Chapter 8 extends the focus to schematic analysis and offers snapshots of Djuna's developing system depicted in schematic networks.

7.2.2 Discussion

Having defined each template and described its behavior, a closer look at Djuna's template use in the context of her overall development is in order. The data reveal the routinization of certain phonological patterns in Djuna's first words. She clearly was working with a limited set of phonological tools, which resulted in a group of utterances that share similar phonetic shapes (e.g., labial-velar, high-low vowel). Utterances using a template are notably similar to each other when compared to utterances that do not use a template.

During the first month of word production, however, eight utterances do not share these shapes. They appear in Table 7.10 and are easily explicable. Seven out of eight of these utterances have a CV syllable pattern with a target-appropriate initial consonant, except for those for *giraffe* (e.g., [ʒa]), which uses the singleton fricative without the stop element [d] of the target affricate [dʒ], and a low vowel, which is only sometimes target-appropriate. The low vowel in these utterances is not target-appropriate in *bubble*, for example, which calls for [ʌ] to follow [b]. The CV pattern with a target-appropriate initial consonant could be argued to be a very basic early template since it is used systematically and functions as a strategy for producing new words whose phonological makeup is too complex for the child's current capabilities and knowledge. Indeed the CV pattern is the first syllable structure children tend to use when they begin producing words because it is the least marked (MacNeilage & Davis, 1990). The other non-templatic utterance during the first month can also be readily explained: [æ], for *eye* [aɪ], is simply a low vowel that infants commonly produce from the time they begin vocalizing.

Table 7.10 Non-templatic utterances produced at age 1;0, given chronologically.

Target word	**Child phonetic form**
'pop'	[pa]
'bubble'	[ba]
'Blackhawks'	[bæ]
'button'	[bʌ]
'giraffe'	[ʒa]
'giraffe'	[dʒa]
'eye'	[æ]
'glasses'	[gæ]

Not only can the non-templatic utterances during the first month of word production be readily explained by production strategies common to children early in development; they also serve to highlight the presence of shared phonological characteristics among the templatic utterances. Evidence for template use is especially robust in utterances whose phonological makeup differs dramatically from target pronunciations. Utterances for *nose* [zia, ʦia] and *bubble* [bʌku] illustrate this point especially well; this effect continues to be seen later in the data—for example, in [naeɪ] for *lion* at age 1;2 and [kai] (two syllables) for *color* at age 1;3, each using the A_ɪ template and resulting in unexpected and unpredictable phonetic forms.

Furthermore, clear connections can be drawn in various ways between the changing proportion of templatic to total utterances, the frequency of use of specific templates, and changes in lexicon size. The proportion of templatic to the total number of utterances is constantly in flux. These changes in Djuna's data set are presented by month in Figure 7.3. In the first month of word production, the number of templatic words in relationship with total words was very high, and then decreased in the next two months, followed by an increase into the subsequent two months (i.e., ages 1;4 and 1;5). Table 7.11 complements the figure by offering the percentage of templatic utterances each month. In the first month of word production, 86% of utterances use a template, and this is if the CV pattern with a target-appropriate initial consonant is not included as a template. Following a decrease in template use in months 1;1 and 1;2, the percentage increases to 25% at age 1;3 and up to 42% at age 1;4. The former is due to increased use of the A_I template, and the latter to a significant spike in the use of the SIBILANT template.

Figure 7.3. Number of utterances using a template (blue) vs. total utterances each month (red).

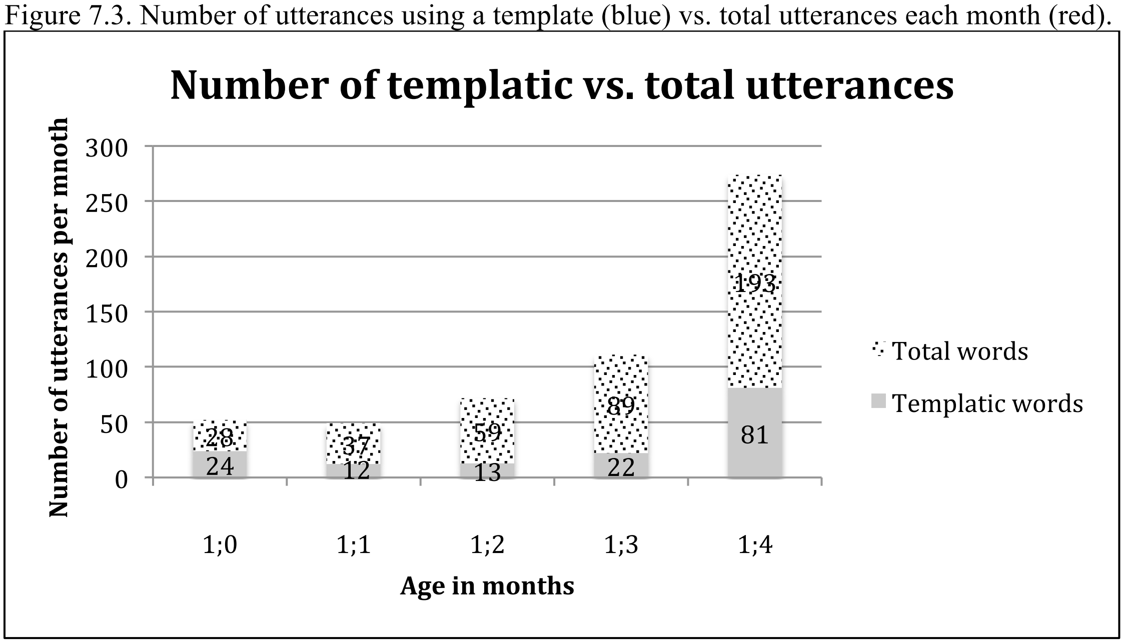


Table 7.11 Percentage of utterances initiated using a template.

Age in months	**% utterances using a template**
1;0	86%
1;1	32%
1;2	22%
1;3	25%
1;4	42%

The distinction between selected and adapted use of templates during these times of fluctuation in the proportion of template use tells us that the child is not simply targeting words with similar phonetic shapes. While many of the target words share some phonetic similarity—attracting the use of a given template, there are periods of high template use when Djuna seems to strategically employ templates to pronounce phonetically divergent new words or to work on new pronunciations of old words. The extension of a template to produce a phonetically dissimilar target word is called adapted use. Recall that this type of templatic behavior is seen to signal the inception of an abstract phonological system whose representational units are used in production (Vihman & Velleman, 2000). During Djuna's first month of word production, when template use was high, she quickly generated 12 distinct words and 28 distinct utterances. At age 1;4, template use increased dramatically following a two-month dip as her lexicon size increased by as many as 80 words. These periods represent phases of systemic reorganization.

Zeroing in on the use of specific templates further refines this argument. During the first month of word production, when Djuna's phonological repertoire was limited to only a few word shapes and a short list of distinct sounds, the LAB-VEL and HIGH-LOW V templates were in heavy use, then dramatically decreased in use the following month at age 1;1. During this second month of word production (age 1;1), the CONS HARM template increased in usage, but was objectively low, used in only just over 10% of utterances. Age 1;1 presents a time of change in Djuna's phonological system. She dropped the templates she had been relying on in the previous month and became somewhat more dependent on another (i.e., CONS HARM). In addition, it was also observed that her use of a CV pattern in production increased from 25% at age 1;0 to 42% at age 1;1. Again, while deeper analysis of developing syllable structure is left for future work, this is an important point because Djuna seems to have left behind two segment-based templates and clung to the CV syllable pattern to aid the production of new words and utterances. During this month (age 1;1), she produced 19 new words and 37 new utterances, an increase upon the previous month.

A given template emerges into use, peaks, and then disappears. That this process occurs hints at the functional role of templates in a child's developing phonological system. In order to classify templates in these data, organized by month, a pattern was required to have been observed in at least 10% of the data in a given month (as in Vihman, 2016), even if this percentage dropped below 10% in other months. Such a drop in use illustrates the fleeting—and dynamic—nature of a template. Template use might be high, as in Djuna's data, when a child's phonological repertoire is extremely limited in the early stages of word production. The data for Trevor, presented in Section 7.3.2, show that template use was not as prevalent as early on as in Djuna's data, which suggests that templates are only part of the picture as a strategy in early phonological and lexical development and that their role differs across children. This suggests, further, that other children use other strategies, highlighting individual variation in paths of phonological acquisition.

In the data of children who rely heavily on templates, like Djuna, the strategy seems to be particularly useful for initiating word production in the face of phonological limitations until additional segmental knowledge and more complex phonotactic knowledge is acquired, which assists the child in fine-tuning the pronunciation of both old and new words. Section 7.2.3 presents analysis of data from E, who early on make use of multiple templates to produce a given word. This is not a strategy that Djuna employs with much significance, but for the purpose of completeness, Figure 7.4 and Table 7.12 show the relevance of this phenomenon.

Figure 7.4 This figure shows rates of the simultaneous use of multiple templates.

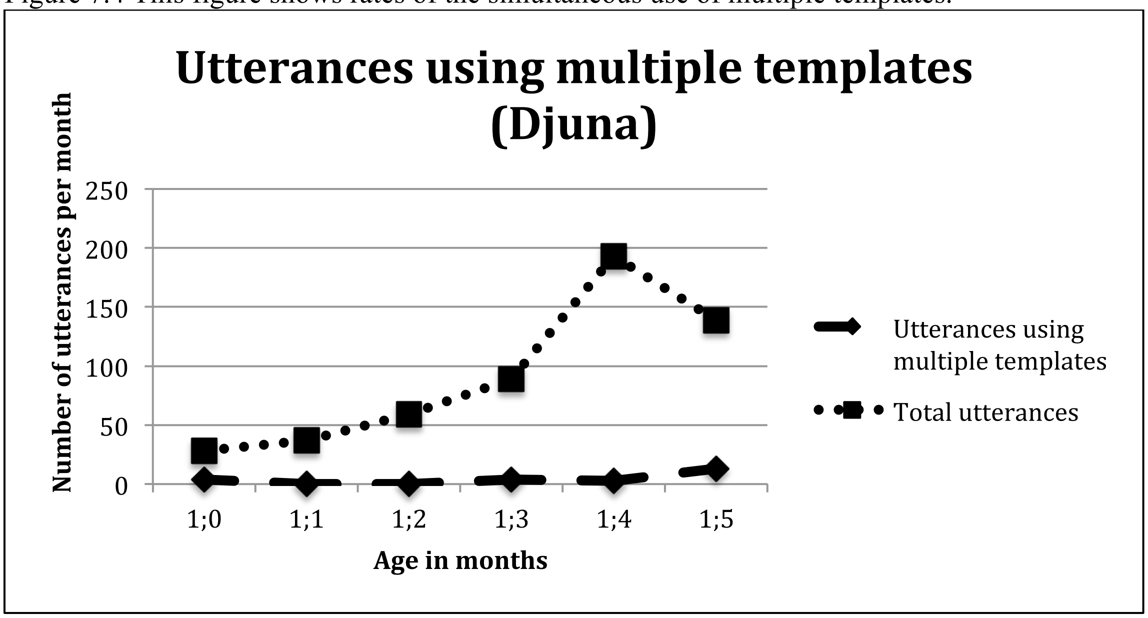


Table 7.12 Data for Djuna's use of multiple templates to initiate a single word.

	Words per month	**Total utterances per month**	**# utterances using multiple templates**	**% utterances using multiple templates**
1;0	12	28	4	14.29%
1;1	19	37	0	0.00%
1;2	27	59	0	0.00%
1;3	40	89	4	4.49%
1;4	80	193	3	1.55%
1;5	73	139	13	9.35%
	178 total	406 total	11 total	4.07% (avg)

Although analysis of Djuna's data focuses on age 1;0 – 1;4, Figure 4 represents data through age 1;5 in order to better illustrate where multiple-template use begins to rise. Table 10 complements Figure by showing changes in multiple template use relative to the number of new words and utterances documented each month. For a comprehensive view of template use in Djuna's developing system, Table 7.13 (see Appendix) provides a list of all templates in use, including a breakdown of both selected and adapted use, and the percentage of each template relative to the total number of words for each month and also overall for ages 1;0 – 1;4.

Drawing from data presented in previous research, it is clear that basic categories of templates (e.g., sibilant, front-back consonant patterns) are found across children as their phonological systems begin to develop. What is different is the phonetic and phonological details both contributing to and realized by the implementation of a template in a child's production repertoire. Data from the other three children in this research, along with a brief templatic analysis, are presented in the following section. The subsequent chapter (Chapter 8) presents the data in schematic networks, illustrating snapshots of each child's phonological system in the early processes of development. The central concepts of dynamic systems theory (as discussed in Chapter 4) help to integrate these theories to depict the emergence of nuanced and idiosyncratic phonological systems.

7.3 Data and templatic analysis: Charlotte, E and Trevor

This section presents data and templatic analysis for Charlotte, E, and Trevor in connection with that for Djuna, described in the previous section. Data for each child were obtained from PhonBank within the CHILDES database (MacWhinney, 2000; Rose & MacWhinney, 2014). First, data for each child are briefly described, followed by a summary of milestones and trends in lexical and phonological development across the four children. The end of this section compares analysis across all four children.

7.3.1 Charlotte

7.3.1.1 Lexical development

Data for Charlotte (Davis & MacNeilage, 1995; Davis et al., 2002) were obtained from PhonBank on the CHILDES database (MacWhinney, 2000; Rose & MacWhinney, 2014*)*. Charlotte began producing words at age 1;1, which is fairly typical. Figure 7.5 shows Charlotte's changes in lexicon size from age 1;1 – 1;8. Advances in lexical development happened gradually until age 1;5, when her lexicon size began to increase more regularly and rapidly. This differs from Djuna's development; Djuna produced 12 words and 28 distinct utterances during the first month and her lexicon size notably increased with each subsequent month. During Charlotte's first month of word production, she produced 2 words: *uh-oh* and *bye*, using 6 distinct utterances. Four variants were produced for *uh-oh* [ʌʔ, hʌʔəʌʔo, ʊʔəʊʔʌʔo, hʌʔhʌʔo], and 2 for *bye* [bæːɪ, bæɪ]. As noted in Chapter 6, no data are reported for age 1;2; it is not clear if no utterances were produced or if no documentation session was held.

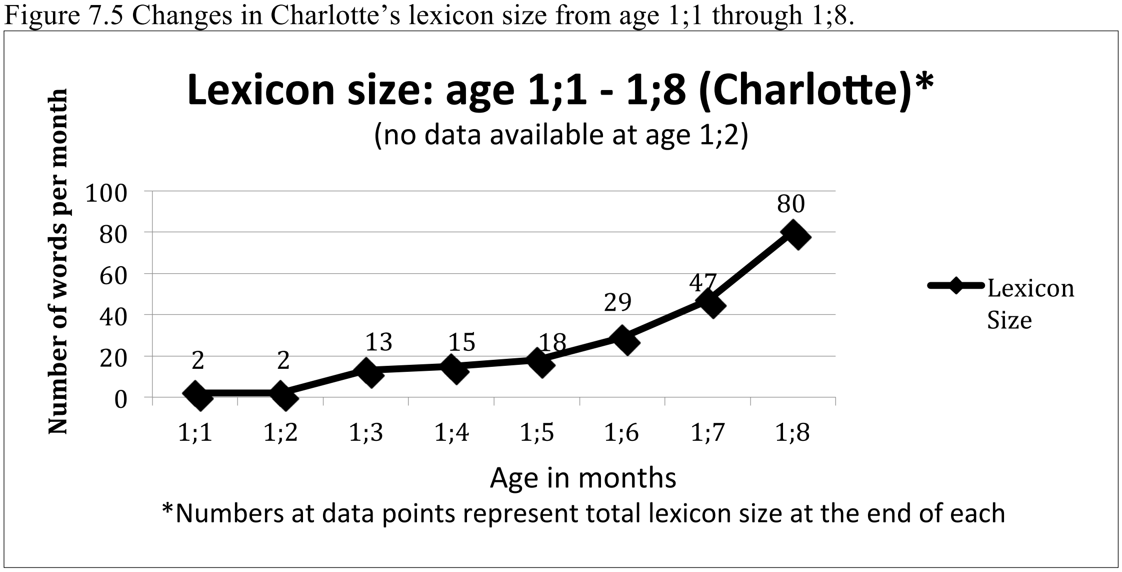
Figure 7.5 reveals three periods of interest during which Charlotte's lexicon size shows marked increase: at ages 1;3, 1;6, and 1;8. At age 1;3, she produced 11 new words, with 47 new utterances, significantly expanding her repertoire. During this month, she produced 9 new consonants and 4 new vowels, shown in Table 7.13.

Table 7.13 Charlotte's inventory of consonants and vowels at age 1;3.

Segment Inventory at age 1;3	
Consonants	f, w, d, t, m, k, p, β, g
Vowels	u, ɔ, ɛ, a

Age 1;3 is the first period of notably increasing lexicon size. Charlotte produced 11 new words at age 1;3, as compared with only 2 new words in both the previous and the subsequent months (age 1;4) of word production. At age 1;6, Charlotte's lexicon size increased by 11 words from the previous month, up from only two additional words at age 1;5; 39 new utterances were produced at age 1;6. Lexical acquisition increased considerably at age 1;8, with 33 new words and 118 new utterances. Changes in template use, to some degree, can inform analysis of these leaps in lexical development in connection with a child's current phonological organization.

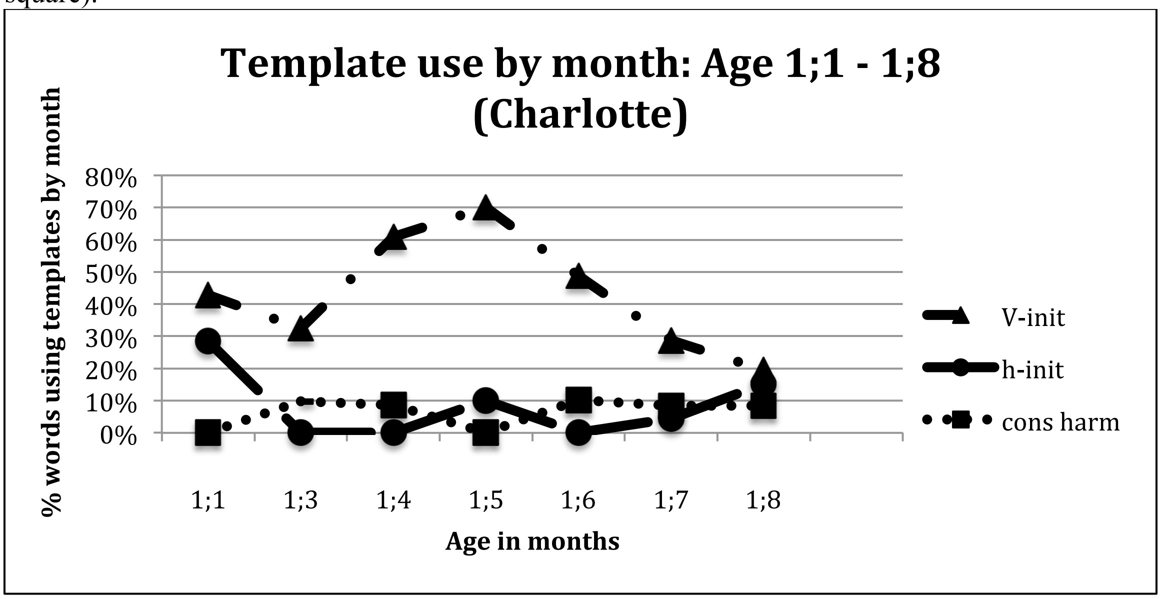
Figure 7.5 Changes in Charlotte's lexicon size from age 1;1 through 1;8.



7.3.1.2 Template development

Three templates were identified in Charlotte's data. Recall that in order for a pattern to be considered a template its use needs to be observed in at least 10% of utterances for the investigation period. Figure 7.6 shows the course of template use during the data period investigated (age 1;1 – 1;8).

Figure 7.6 Three templates identified in Charlotte's data collected from age 1;1 through 1;8: V-INIT (dashed-dotted line, triangle), H-INIT (long-dashed line, circle), CONS HARM (dotted line, square).



In the first month of word production both a vowel-initial (V-INIT) and an h-initial (H-INIT) template are in prominent use. Since no data were documented for age 1;2, this month is excluded from the figure. A drop in the use of the H-INIT template is seen between the first month of word production (age 1;1) and age 1;3. At age 1;3, the V-INIT template shows an increase in use, following a decrease, and a consonant harmony (CONS HARM) template emerges, though it is never very prominent, as in Djuna's data. Examples include [bæbə], [tatu], and [dedʌ], all targeting *thank-you*. At age 1;4, a notable increase in the V-INIT template is seen (from 32% to 61% of total utterances). During this month, Charlotte acquired only 2 new words but used 23 new utterances. This suggests the deployment of her current set of phonological tools in a variety of patterns to work on the pronunciation of words previously acquired. At age 1;5, the use of all templates began to decrease as lexicon size rapidly increased. Changes in Charlotte's segment inventory and rates of production accuracy might offer some explanation for this trend, although these measures are not part of the present analysis.

The V-INIT template is characterized by an utterance beginning with a vowel. While this characterization might at first seem too minimal, tracing the pattern into development offers justification. The template is seen in the child's first documented utterance: [ʌʔo] for *uh-oh* (selected use). This could simply be described as an accurate rendering of the adult target word if not for subsequently documented data. An increasing preponderance of inaccurate vowel-initial utterances reveals the pattern developing as a templatic strategy. At age 1;3, for example, Charlotte produced [æku] for *thank-you*. This is the first adapted use of the template. At age 1;6, she produced [əʒi] for *bee* and [ɪbʌk] for *book*. It is not clear why she substituted [ʒ] for [b] since her data demonstrate that she is capable of producing [b]; neither is it clear why [ɪ] is epenthesized word-initially to produce *book*, except that numerous utterances began to occur vowel-initially, both accurately and inaccurately. Some of the V-INIT utterances, like that for *thank-you*, are V-INIT by way of initial consonant omission; the utterances for *bee* and *book* at age 1;6, noted above, are V-INIT by way of an epenthetic initial vowel. Later, at age 1;7, Charlotte produced the utterances in (1), employing both strategies, for *cookie(s)*:

(1) [ʌkis] (initial consonant omission)
[aki] (initial consonant omission)
[əkʊki] (epenthesis)
[adʊki] (epenthesis)

These vowel-initial utterances are contemporaneous with non-V-INIT utterances for *cookie(s)* that are alveolar-initial (e.g., [tʊki]). Table 7.14 shows the number of V-INIT utterances in selected and adapted use of the pattern. Up through age 1;6, V-INIT utterances were used mostly accurately (93% accuracy); then at age 1;7, the scales tipped and more adapted than selected uses of the pattern occur, representing 28.79% (19/66) of the total utterances for that month.

Table 7.14 Number of selected and adapted utterances using the V-INIT template from age 1;3 – 1;7.

Age	Selected	Adapted
1;3	12	1
1;4	14	0
1;5	7	0
1;6	16	3
1;7	8	11

It seems likely that these utterances were influenced by the child's numerous attempts at *again*, which occur in several forms, including [əgɪ] and [ægɪ], and even [edɪ] with a medial alveolar consonant. Transcribers for this study, unlike the study of Djuna, documented repeated utterances for the same referent. Attempts at *again* dominate the first few months of word production, particularly at age 1;6, when utterances for *cookie(s)* begin resembling those for *again*, even though their adult target forms are not similar in segmental, syllabic, or prosodic composition. The preponderance of vowel-initial words supports calling Charlotte's production behavior a template. This behavior can be described by the principle of attraction as described within dynamic systems theory in Chapter 4. That is, the pattern having developed in the child's burgeoning phonological system serves as an attractor, resulting in its increasing use in the production of new words. Many V-INIT utterances employ a more specific pattern fitting to VCi (as in the lower three in (1)), but other, less uniform patterns are also seen. For example, at age 1;7 Charlotte produced [əβjeə] for *tiger* and [əbæ] for *Benny*. Utterances using the V-INIT template can be categorized into sub-patterns that can be effectively visualized in networks of schematic patterns (see Chapter 8).

The V-INIT template receives the most attention in the analysis of Charlotte's data because it dominates the period of phonological development examined here. The data also exhibit an H-INIT pattern characterized by h-initial words, both accurately in selected use (e.g., [hʌp] for *help*) and less accurately in adapted use (e.g., [hes, his] for *please*; [hʌp] for *up*; [hʌbaʊ] for *ball*). Adapted use typically results in either substitution of the initial consonant (e.g., [hes, his] for *please*) and in epenthesis (e.g., [hʌp] for *up*; [hʌbaʊ] for *ball*). The pattern was used only minimally until age 1;8 when it peaked (used in 15.25% of utterances for that month). While the role of the H-INIT template has only a small role in Charlotte's developing phonology, it is described here because it consistently results in unexpected h-initial utterances relative to targets; furthermore, the template also appears in data for E (see the following subsection).

Returning to the three points of interest introduced early in this subsection, at age 1;3 when Charlotte's lexicon size increased so did her use of the V-INIT and CONS HARM templates. Utterances using a template comprised 47.5% of her total utterances. Age 1;6 was accompanied by a drop in the use of all active templates, including the beginning descent of the V-INIT template. Despite the drop in template use relative to the temporal course of development, as much as 69.23% of utterances used a template. In addition to acquiring 11 new words, she also added 39 new utterances, reflective of intensified and varied production efforts. At age 1;8, 52.43% of the total utterances used a template, and all three templates were used with some frequency, indicated in Table 7.15:

Table 7.15 Percentage of utterances using the V-INIT, H-INIT, and CONS HARM templates at age 1;8.

TEMPLATE	% UTTERANCES
V-INIT	19.49%
H-INIT	15.15%
CONS HARM	8.47%

7.3.1.3 Discussion of trends and periods of interest

Interestingly, template use was highest at ages 1;1, 1;4, and 1;5 when lexical acquisition was lowest. The concurrence of high template use, a high utterance count, and low lexical acquisition supports the notion that routinized patterns can serve as temporary strategies to practice acquired sounds and patterns to produce words as a phonological system takes shape. Since this is not the trend seen in Djuna's data, however, nuance is required to understand the function of templates. At age 1;4, Djuna acquired 80 new words and used 193 new utterances, with utterances only slightly higher in proportion to new words relative to other months; at the same time, all but one template declined in use. That one template—the SIBILANT template—on the contrary, soared in use, becoming quite important in her developmental trajectory. During the period Charlotte relied heavily on one template (i.e., V-INIT, age 1;4 and 1;5), the acquisition of new words slowed while she seemed to work on pronunciations of old words, as is reflected in the high number of utterances during these months. Where Charlotte seems to have used templates to refine the pronunciation of old words, Djuna used templates to facilitate the production of new words.

7.3.2 Trevor

7.3.2.1 Lexical development

Data for Trevor (Compton & Streeter, 1977; Pater, 1997) were obtained from the PhonBank portion of the CHILDES database *(*MacWhinney, 2000; Rose & MacWhinney, 2014). Trevor began producing words early relative to the average, at age 0;8. At this age, one word was documented: *dog*, produced as [aʔ], in which the initial consonant was omitted from the target CVC pattern and the final consonant was glottalized. Figure 7.7 shows changes in Trevor's lexicon size during the investigation period. During the second month of word production, 2 words with 3 distinct utterances were documented, and during the third month 3 new words with 3 new utterances. Similar to Charlotte, and to E (discussed below), Trevor's lexicon size increased only gradually during the first few months of word production. Around the third month of word production, at age 0;11, Trevor's lexical and phonological acquisition began to take off. During this month, Trevor produced 11 new words with 23 distinct utterances, directing much of his articulatory practice to pronouncing *banana*, *cookie*, and *clock* (Table 7.16). In doing so, he produced many homonymous forms among attempts at *cookie* and *clock* (e.g., kæ, ɣɪ); at age 1;0, he also produce [x] and [kæk] for *cookie* as he did for *clock* at age 0;11. This production behavior serves as support for the presence and use of routinized patterns affecting whole words. Recall that an utterance gets counted when it has not before been used as a phonetic form for a given word. This can result in homonymous forms, which can be ascribed to the use of a template to anchor the production of a new word.

Figure 7.7 Changes in Trevor's lexicon size from age 0;8 through 1;3.

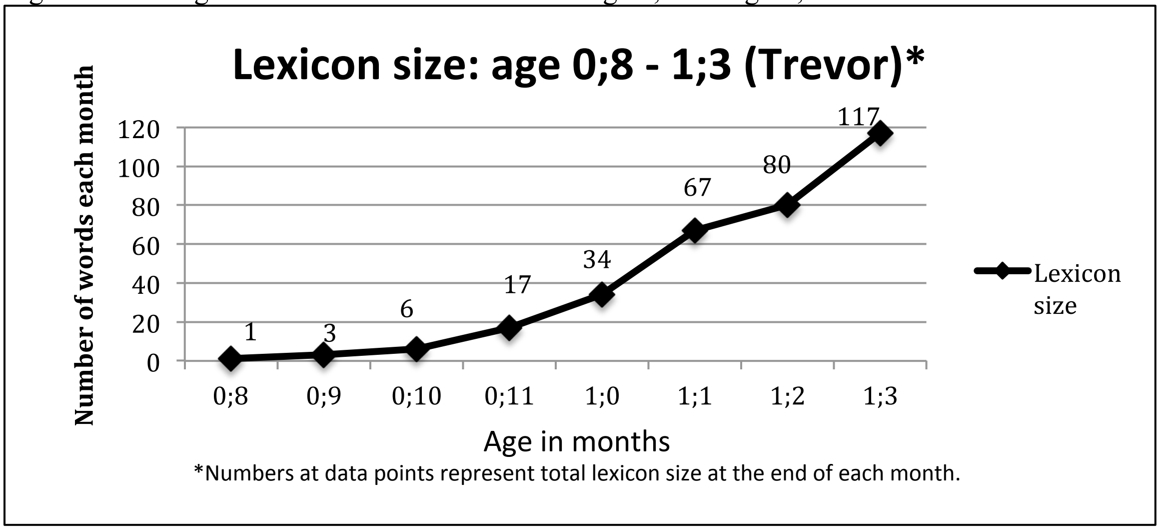


Table 7.16 Selection of utterances produced for *banana*, *cookie*, and *clock* at age 0;11.

banana	***cookie***	***clock***
nænə	kæ	kæ
nʌnʌnʌ	ɣɪ	kæk
anə	kækæ	x
ænə		ɣɪ
nanə		

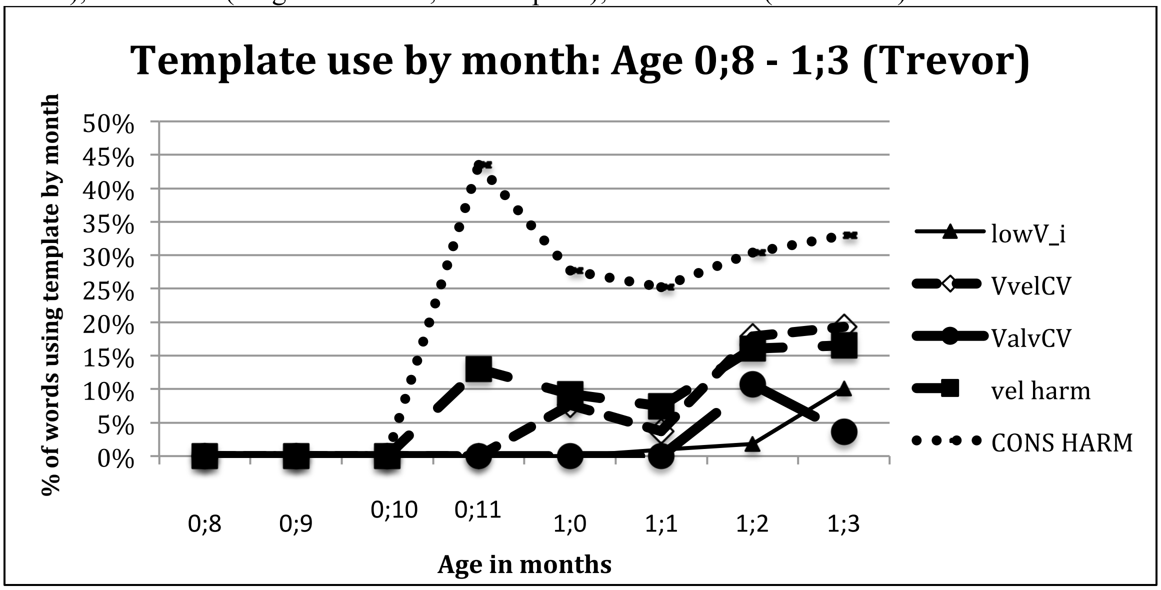
7.3.2.2 Template development

Examination of changes in lexicon size and utterance counts per month, in connection with changes in template use per month, reveal interesting relationships in Trevor's development. These relationships are reflected in Table 7.17, which provides the number of new words and number of new utterances produced each month, and in Figure 7.8, which shows changes in template use during the investigation period.

Table 7.17 Number of words and distinct utterances documented in each month.

Age	Words	Utterances
0;11	11	23
1;0	17	65
1;1	33	107
1;2	13	56
1;3	37	109

Figure 7.8 Five templates identified in Trevor's data from age 0;8 through 1;3: LOWV_I (thin line, filled triangle), VVELCV (short-dashed line, empty diamond), VALVCV (dashed-dotted line, filled circle), VEL HARM (long-dashed line, filled square); CONS HARM (dotted line).



From age 0;11 to 1;1, Trevor's lexicon size consistently increased each month, with 17 new words at age 1;0 and 33 at age 1;1. At age 0;11, which marks the first observed template use, the number of utterances was approximately double that of newly acquired words, but at age 1;0, the number of utterances is closer to four times that of new words. During this month, when the number of new utterances was quite high, a notable decrease in template use was observed. This trend differs from Charlotte's data, where a low number of new words and high utterance counts (relative to words acquired during a given month) were accompanied by high template use. Even with a decrease in Trevor's template use at age 1;0, 40% of utterances were nonetheless produced with a template. It could still be concluded, as with Charlotte, that in a period of decreased lexical acquisition, Trevor made substantive use of templates to work out new pronunciations of old words. In contrast, the use of at least one template is high across the investigation period for Djuna, and even during the lowest period of template use (age 1;2, 22% of total utterances) the proportion of utterances varies only inconsequentially.

At age 1;2, Trevor acquired only 13 new words, and then the following month added 37 words to his lexicon. The dip in lexical acquisition at age 1;2 suggests a disruption or temporary plateau. A decrease in the number of new distinct utterances also occurs at age 1;2, but is proportionate with the decrease in new words. What is different about age 1;2, relative to other months, is that template use is higher than in any of the other months. Among the total utterances produced at age 1;2, 71% use templates. In this month, similar to what is seen in Charlotte's data, high template use is accompanied by a large number of new utterances, but a low number of new words. This suggests that at age 1;2 templates facilitated practice at target pronunciation rather than lexicon building. Templates active at this time include consonant harmony, velar harmony, and a general VCV pattern whose C is specified in two ways, either as alveolar or velar.

Three templates, in addition to a group of consonant harmony templates, were identified in Trevor's data. Figure 7.8 shows changes in specific template use over the course of the investigation period. The first obvious point to make is that templates were not identified to have been in use during the first three months of word production. During this three-month period, Trevor acquired only 6 total words and 7 distinct utterances, so production was quite low during this initial period when templates were not in use. Since templates are considered to be schematic whole-word representations generalized from production practice, it makes sense that templates were not identified with so little content from which to generalize. Of course, this leaves one to consider differences in Charlotte's and Trevor's incipient phonological systems, since emergent templates were identified in Charlotte's first month of production, when she produced only 2 words.

Throughout the course of the investigation period, data from Trevor exhibited several different specifications of consonant harmony. These specifications include velar, alveolar, labial, and nasal harmony, among others. In order to accurately track template use in Trevor's developing phonological system, calculations of the number of utterances for each individual type of harmony and all utterances using consonant harmony together were carried out. When all utterances using consonant harmony were calculated together, this production strategy was the most prominent among templates, emerging into use at age 0;11, during which time 48% of utterances can be described as templatic compared to no templatic utterances the previous month. Templatic utterances during this month, however, might better be described as emerging-templatic since all occur in selected use. Recall that when a template is used to select a word for production, its schematic phonological content matches the phonetic content of the target word. For example, Trevor produced [kæk] for *clock*. The target word contains identical consonants in different positions; while there is no need for assimilation, per se, since the target consonants already share qualities, a pattern is nevertheless being established. Accepting that children typically reduce a target cluster like [kl] to [k] by omitting the more sonorous consonant, as Trevor does here, this utterance can be described as accurate.

In the scope of the developing system, the harmony pattern is the beginning of a strategy used to produce other words, some accurately and some inaccurately. At age 1;0, Trevor employed the strategy to produce [gægæ] for *hungry*, inaccurately in adapted use of the consonant harmony template. It becomes clear that consonant harmony is a strategy to produce new words when an increasing number of additional utterances occur in its adapted use. For Trevor, the prominence of consonant harmony decreases at age 1;3, but nevertheless comprises at least 25% of utterances at any given point during the investigation period. Velar harmony, demonstrated in the two examples given here, was the most prominent of the specified consonant harmony patterns in use, constituting 16% of utterances at age 1;2 and 1;3, and is discussed further below.

In addition to this group of consonant harmony templates, Trevor also relied on a pair of related patterns that can be considered to be specified forms of a more general VCV pattern: VVELCV and VALVCV. The first is a vowel followed by a velar consonant followed by another vowel, as in [ɔgɔ] for *all gone* (selected use) or [gɪga] for *guitar* (adapted use). Note that the form for guitar also employs the velar harmony template, assimilating the alveolar C_2 to the velar C_1; note, also, that the VCV pattern is embedded (or merged with) a larger CVCV pattern. The VVELCV pattern is identified as a pattern separate from velar harmony because, as in the example of selected use of the template, it is not always concurrent with the use of velar harmony. The velar harmony pattern, which again is prominent among Trevor's data, most frequently occurs in a CVCV pattern, and Trevor relies on it quite heavily in his many attempts to produce both *guitar* and *pine cone*, whose child forms come to sound similar to one another. This is common during the templatic period of representation (Vihman & Wauquier, in press: 1), and is another phenomenon that can be explained well by the notion of attractors within dynamic systems theory (Thelen, 1995; Thelen et al., 1991; Thelen & Smith, 1994).

Trevor's attraction to velar patterns in general is one of the two most interesting characteristics of his phonological system and is crucial to understanding his developmental course. A number of words targeted early on for production are velar-initial (e.g., *get down, girl, give, goat, get it, gone, good*) and others accurately use velar harmony (e.g., *cookie, clock, cracker*). Table 7.18 lists words produced with velar harmony, including many unpredictable child forms. The age during which utterances were documented is included in order to present a timeline for when the velar harmony pattern was active and to illustrate when and how a routinized templatic pattern was likely used to facilitate and refine the production of new words, clustered within a definable period of time. The first is seen at age 1;0.15 for *egg* [gʌgæ] up through *napkin* [gæki, gæːkɪ.ə] at age 1;3.17, before attempts at the latter word become more adult-like (e.g., [nækæ]). Trevor exerts much effort to produce *guitar* and *pine cone*, and from age 1;2.6 through nearly the end of that month, attempts at these words often result homonymously in [gaka] or [gaga]. Attempts at *vacuum* also frequently result in [gaka], during this period. Utterances using the VVELCV pattern are also seen in this table (see *eye*, *all gone*, and *airplane*); these target words are vowel-initial, matching the template. Another phenomenon to note here is the interspersion of forms containing either an initial or medial alveolar consonant, in some cases along with velars (e.g., [dɛke] for *airplane*, [gædɪ] for *blanket*) and in other cases using alveolar harmony (e.g., [dætɪ] for *blanket*, [dɪtaʔ] for *diaper*). Velar-alveolar sequences may have been influenced by Trevor's accurate utterances for *get down* (e.g., [gɛːtau , gɛːdau]), produced concurrently. Interestingly, between age 0;8.28 and 0;11.16, the only initial and medial consonants Trevor produced are velars and alveolars; he produced glottal stops [ʔ] word-finally in several utterances.

Table 7.18 Child forms using velar templates from age 1;0.15 to 1;3.26.

Target word	Child forms	Age during which velar harmony is used
egg	[gʌ, gʌgæ]	1;0.15
eye	[aigə, aː, ɔi]	1;0.11 – 1;2.6
hungry	[gægæ, gugugu, gʌgʌgʌgʌ]	1;0.25 – 1;1.17
guitar	[gi, giʃ, kæga, kæ, ga, gæka, gɪga, gaga, gaka]	1;1.13 – 1;2.24
pine cone	[go, gaigo, gago, gogo, gako, gaka, gægo, gɔgɔ, gaga, ko]	1;2.6 – 1;3.4
vacuum	[gaka, ga.n, ga.n̩n, ga.n̩, gaka.n̩]	1;2.16 – 1;3.25
blanket	[dætɪ, dætɪ, gægɪ, dætɪ, gækɪ, dækɪ, gædɪ, dɛtɪ, kaiki, ʤɛʤɪ]	1;2.26 – 1;3.21
all gone	[ɔgɔ, gɔgo, gagɔ, gægo]	1;3.1 – 1;3.26
airplane	[gɛke, dɛke, daki, gɛke, aga, giʧə, dɛʤɛ, gægai]	1;3.4 – 1;3.25
diaper	[dɪtaʔ, gikɪ]	1;3.10
bottle	[gago]	1;3.10 – 1;3.26
napkin	[dæti, gæki, gæːkɪ.ə, nɪnɪ.k, nækæ, nænɪ]	1;3.17

This is a suitable place to turn to the second pattern introduced above (VALVCV), defined by a vowel followed by an alveolar consonant followed by another vowel. Similar to the relationship between velar harmony and the VVELCV pattern, a pattern of alveolar harmony was active in Trevor's developing system but was not nearly as prominent as velar harmony; at age 1;2, the alveolar harmony strategy was at its highest use in 7.14% of utterances for that month. The VALVCV template also reached its highest usage during this month, at 10.71%. Analogous to the VVELCV pattern, the VALVCV pattern occurred sometimes on its own and sometimes embedded (or merged) within alveolar harmony (see Table 7.19), and utterances using this pattern clustered around the same period of time. Utterances using only the VALVCV pattern were produced for *uh-uh*, whose target pronunciation begins with a glottal stop [ʔ], although difficulty perceiving word-initial glottal stops (as for *eye*, *all gone*, and *airplane* above) is common. Utterances for *cat* (selected use) and *cup* (adapted use) use a velar-alveolar sequence that carries a VALVCV pattern. The data in the table are limited, but it is notable that Trevor temporarily clung to this pattern during a short yet definable period of time, from 1;2.13 – 1;3.11. Conceptualizing the phenomenon in terms of dynamic systems theory, the pattern can be viewed as only a moderately stable attractor, given its fleeting livelihood in the system. A more complete analysis will address a view of the entire phonological system before, during, and after this pattern emerged and dissolved in order to follow the system's reorganization processes. This line of research is left to future work.

Table 7.19 Utterances using the VALVCV template

Target word	Child forms	Age during which utterance was produced
cat	[kætə]	1;2.13
cup	[kʌtə]	1;2.20 – 1;3.10
uh-uh	[ʌtə, ata]	1;2.26, 1;3.1, 1;3.11

7.3.2.3 Discussion of trends and periods of interest

The most informative periods in Trevor's development come at age 0;11, when he initiated template use, and from age 1;1 – 1;3, when there are striking changes in lexicon size and the number of distinct utterances per month in connection with changes in template use. At age 1;3, the velar harmony patterns remained consistent at 16.51% of utterances while the VVELCV pattern decreased in use to 19.27% of utterances. A logical prediction is that, even if the child continued to rely upon a velar harmony template in both selected and adapted use after the VVELCV dropped out of use, the phonetic complexity found in utterances should expand beyond the VVELCV pattern. Indeed at age 1;2, 11 different patterns were found to be in use, while only four were used with enough frequency to meet template criteria; in contrast, at age 1;3, 14 different patterns were found to be in use, with only three meeting template criteria. These numbers do not reflect accurate utterances or utterances with phonetic sequences that were used too infrequently to gain template status. These trends reveal that where production had clustered around a strong set of routinized patterns at age 1;2, Trevor's articulatory efforts opened up at age 1;3 to cover more phonetic ground as his system was becoming more complex. A more complete future analysis will also factor in Trevor's consonant and vowel inventories during these periods, along with rates of accuracy in production.

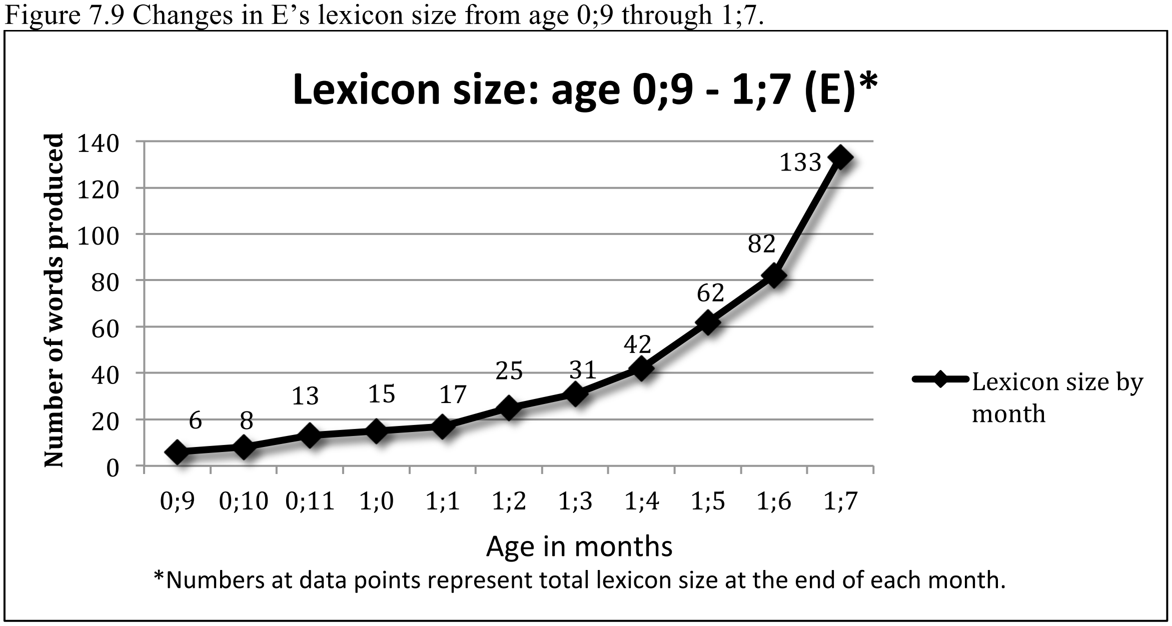
Trevor's data, like that for Charlotte, highlight differences in templatic patterns among children and also different patterns of template use in connection with other templates and the production of new words and new pronunciations of old words. In the following chapter (Chapter 8), the velar harmony and VVELCV patterns illustrate degrees of abstraction in developing schematic structure, offering a snapshot of fleeting phonological organization along the path of acquisition. The data offer support for the utility of the schematic model by showing that schematic representation, particularly as it is interpreted through dynamic systems theory, can effectively depict emergent phonological patterns subject to the property of self-organization, and developing, interacting, and, in some cases, dissolving in real time.

7.3.3 E

7.3.3.1 Lexical development

The child called E (Inkelas & Rose, 2003; 2008) began producing words early at age 0;9, relative to what is typically seen in children. During the first month of word production he produced 6 new words and 14 distinct utterances, generating 9 consonants (b,w,ɣ, l, m, k, t, ʔ, h) and 2 vowels (ɑ, æ). Figure 7.9 shows the course of change in lexicon size from age 0;9, at the onset of production, through age 1;7. The child's first word was *ball*, and six sequential variant utterances are documented. These are followed by an attempt at *flower* [blɑ]. The b-initial form could be attributed to the child's incipient routinization of a b-initial pattern initiated in the utterances for *ball*. The next word attempted—accurately—was *mama*, employing a nasal bilabial [m]. The initial consonant in the rest of the words produced during the first month was produced back in the articulatory space as velars (e.g., [k]) and glottals (e.g., [h]). During the following month, production was minimal, with only 2 new words (*there* and *mommy*) and 3 distinct utterances (*there* [dʲæː, dæː]; *mommy* [mæmæ]). In contrast with Djuna, who produced 19 new words during her second month of production, the other three children investigated here (Charlotte, E, and Trevor) added words more gradually in their second month, with only 2 or 3 new words, and in the case of Charlotte possibly no new words.

Figure 7.9 Changes in E's lexicon size from age 0;9 through 1;7.

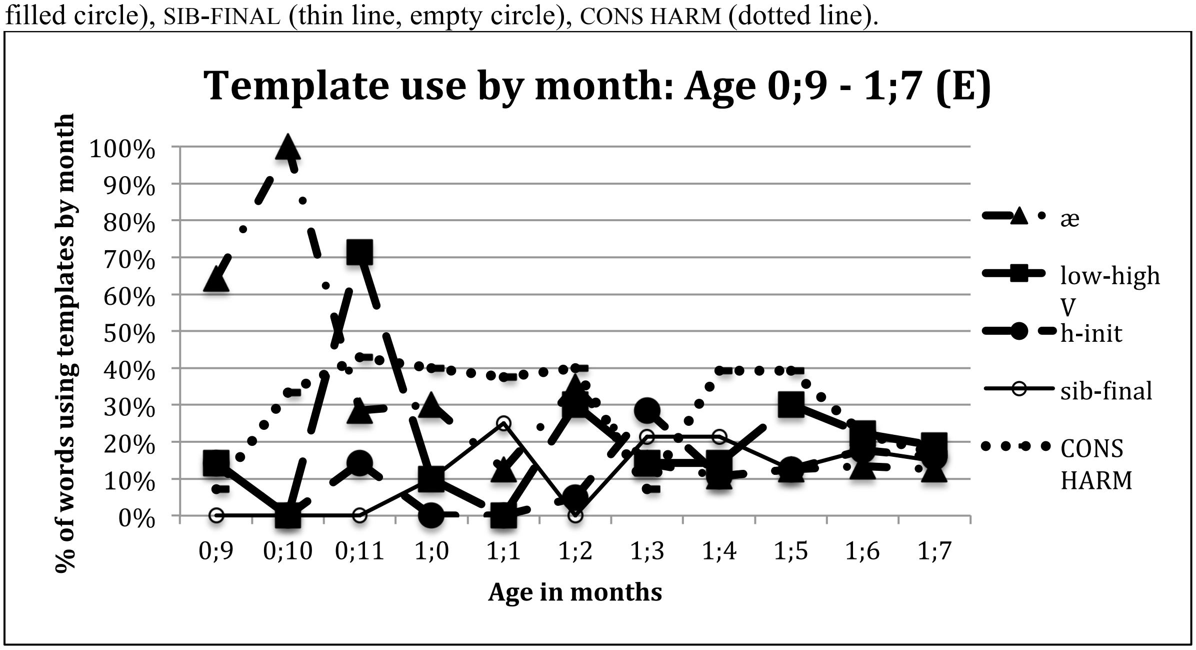


E continued to add words to his lexicon at a slow pace until age 1;4. From age 1;3 – 1;4, his lexicon size increased by 11 words, and then in the following month (age 1;5) increased by 20 words. After this point, lexical acquisition began to happen rapidly for E, with 51 words added at age 1;7. If templates were being used as a strategy to facilitate word production, one would expect their use to be somewhat high at this time, relative to non-templatic utterances, during these months of rapid lexical acquisition. This is not the case for E; at these points only about a quarter of utterances use templates as routinized patterns of production. This figure is notable, but template use is particularly high at ages 0;11 and 1;2. At age 0;11, E produced 5 new words (up from 2 the previous month) and 7 new utterances; at age 1;2, he produced 8 new words, with 20 new utterances. Months during which the number of new utterances is notably higher than that for new words are of interest because it suggests the child was working on his pronunciation of certain words while expanding his repertoire of phonotactic patterns. Because of this, ages 0;11, and 1;2, along with months of notable increase in lexicon size (ages 1;5 and 1;7) are periods of interest.

7.3.3.2 Template development

Five prominent patterns were identified in E's developing phonological system during the period between age 0;9 and 1;7: æ (Æ), low-high vowel (LOW-HIGH V), h-initial (H-INIT), sibilant-final (SIB-FINAL), and consonant harmony (CONS HARM). Figure 7.10 shows the percentage of utterances using each template during each month in the investigation period. The template described as Æ is defined by the presence of this vowel in an utterance. Similar to the V-INIT and H-INIT templates in Charlotte's system, the presence of this one sound defining a pattern of usage becomes clear by tracing its routinization in an increasing number of utterances, particularly in adapted use, which results in unpredictable and inaccurate forms. During the first month of production 64% of the 14 utterances were shaped by this vowel. All three utterances in the second month of production used this vowel, and then its use tapered off until age 1;2, when 35% of 20 utterances were produced with this vowel. Selected use of the template includes [bæ] for *bath* (age 0;9) and [dædæ] for *daddy* (age 1;0); adapted use includes [dæː] for *there* (age 0;10), [jæʌm] for *yum* (age 1;1), and [dædu] for *bye-bye* and [æpu] for *up* (age 1;2). Accuracy in vowel production is neither expected from a child this early in development nor confirmable in a diary study without recordings for acoustic analysis. The vowels in this child's utterances, nevertheless, gravitate toward this vowel whether it is part of the adult target word or not, suggesting its function as an attractor, a temporarily stable preferred behavioral state (Thelen, 1995), as the child advances his production repertoire.

Figure 7.10 Four templates identified in E's data collected from age 0;9 through 1;7: Æ (dashed-dotted line, filled triangle), LOW-HIGH V (long-dashed line, filled square), H-INIT (dashed line, filled circle), SIB-FINAL (thin line, empty circle), CONS HARM (dotted line).



The LOW-HIGH V template consists of a sequence of two vowels, in some cases interrupted by a consonant, in which the first is produced high and the second low in the articulatory space. Here “high” and “low” are defined relative to one another, as in Djuna’s data. Selected use is seen in utterances like [hæːɪ] for *hi* (age 0;11.5), and adapted use is seen in the following utterances: *peek-a-boo* [babu] (age 0;11.27), *that* [dadu] (age 1;2.4), and *up* [æpu] (age 1;2.24). This template saw three peaks at ages 0;11 (57.14%), 1;2 (30.00%), and 1;5 (30.00%), coincident with increases in lexicon size; the percentage of utterances using the template each month is in parentheses. These percentages are high but should be put in perspective; E’s lexicon size was relatively small, and the number of utterances produced each month was low, until age 1;5. The force of the template peaks at ages 0;11 and 1;2 may have been associated with change in lexicon size; 5 words were added at age 0;11 and 8 words were added at age 1;2, which is high relative to the respective preceding months during which only 2 words each were added. Other factors, including the influence of other templates and of consonant and vowel inventories at ages 0;11 and 1;2, need to be more closely examined to gain a fuller perspective on why the use of this template increased at these times. Age 1;5 is also a period of noteworthy change in E’s lexicon and phonological system, when 20 new words were added. The lexicon size grew rapidly from this point. While the use of any given template was not very high at age 1;5, four templates were in use at over 10% of utterances, which again is the criterion for establishing templatic behavior. It seems likely that E employed templates, as phonological representation affecting whole words, to initiate the production of an increasing number of new words at this time.

Like Charlotte, E also employs an H-INIT template. Examples of selected use include frequent attempts at *hi* (e.g., [hæːɪ], age 0;11.5) and *hello* ([howoʊ], age 1;3.16). Adapted use is seen in attempts at several words, shown in Table 7.20:

Table 7.20 Utterances exhibiting adapted use of the H-INIT template.

Age	Target word	Child form
1;3.20	thank you	[hɛɪ hoʷ]
1;4.14	moon	[hʲuːm]
1;5.3	snake	[hjeɪ]
1;5.11	fish	[heɪʃ]
1;6.18	shoe	[huːʃ]

Similar to data in Jaeger (1997; see Chapter 3), a templatic explanation can be offered for the metathesis of the [ʃ] seen in the utterance for *shoe*. This H-INIT template, as in Charlotte's data, is defined by the repeated employment of H-INIT forms, both accurately and inaccurately over the course of development, which justifies its status as a template despite its minimal presence in the developing system. When Charlotte employs the template, the result is word-initial segmental substitution or initial segment or syllable epenthesis. In contrast, E's use of the H-INIT template results in word-initial segmental substitution only. A contrastive study of this template in context with Charlotte's and with E's developing phonological systems would enrich analysis, particularly in view of Preistly's (1977/2013) observation of a medial-[j] template in data for the child Christopher. Due to its minimal impact on E's system on the whole, the H-INIT template is not discussed further here.

Another point of interest for the use of the H-INIT template is in connection with E's SIB-FINAL template. As suggested by its name, this template is defined by utterances ending with a sibilant. This template reaches its highest peaks in usage at ages 1;1, 1;3, and 1;4. While it never becomes hugely prominent, in 25% of utterances at age 1;1, it registers a consistent presence over the course of the investigation period. Examples of selected and adapted use appear in Table 7.21. This selection of SIB-FINAL utterances is representative of the use of the template as revealed by E's data. Most utterances using the template are categorized as selected rather than adapted use, which put into question whether or not the repeated occurrence of sibilant-final utterances constitutes a template or just accurate articulation of sibilant-final target words. It is included here as a template because (1) adapted use of it suggests at least low-level representational status, and (2) it becomes a sort of companion template to the H-INIT pattern. The H-INIT template is first seen when E is aged 0;9.8, and the SIB-FINAL template is first seen when E is aged 1;0.29. Each template remains in use but fluctuates over the course of the investigation period. The first occurrence of both templates used together is seen when E is aged 1;5.11: *fish* [heɪʃ]. A developing schematic network depicting the interaction between these two patterns appears in Chapter 8.

Table 7.21 Selection of utterances using the SIB-FINAL template.

Age	Child form	Target word	Selected/Adapted
1;0.29	dejiʃ	*there*	adapted
1;1.9	dɪʃ, ʤɪʃ	*fish*	selected, selected
1;3.20	ʧiʃ, ʤiʃ	*cheese*	selected, selected
1;4.17	ʂɪʂɪʂ	*scissors*	selected
1;4.17	ʂiʃ, ʂiʒ	*fish*	selected, selected
1;4.28	næs, næʃ	*nurse*	selected, selected
1;5.11	heɪʃ	*fish*	selected
1;6.18	hu:ʃ	*shoe*	adapted
1;7.9	haʧ	*thanks*	selected

A group of CONS HARM patterns also occurs in E's data. More prevalent than in Djuna's or Charlotte's data, this strategy seems to have supported E's articulatory efforts through the first 11 months of word production. Between age 0;10 – 1;2, the use of this strategy ranges and is seen in between 33% and 43% of total utterances for a given month. Specified variants of consonant harmony were identified, including harmony of place (alveolar, velar, labial) and harmony of manner (sibilant, nasal) and warrant closer scrutiny. This task lies outside the scope of the present work, although the data could substantially inform a future study examining variable consonant harmony strategies across children in the early months of word production.

The phenomenon of multiple-template use, which was observed in E's data, warrants discussion here. The simultaneous use of multiple templates to produce a given word was increasingly observed throughout the investigation period. The interaction between the H-INIT and SIB-FINAL templates was described above, and other patterns were observed to interact earlier on in E's development. While merging patterns were first noted at the end of the investigation period for Djuna, the phenomenon is seen in E's first month of production. Figure 7.11 shows E's increasing simultaneous use of multiple templates from age 0;9 to 1;7, including a marked increase from age 1;6 – 1;7. Any utterance in which more than one pattern determined to be a template was used is referred to as multiple-template use. Typically this means two templates are used (e.g., Æ and LOW-HIGH V templates, as in [æpu] *up*), but sometimes three templates are used (e.g., Æ, H-INIT, and SIBILANT-FINAL templates, as in [hæs] *thanks*). Examples of utterances using the H-INIT and SIB-FINAL templates individually and combined are shown in Table 7.22. Utterances using multiple templates, or templates in combination, follow a course nearly matching the increases and decreases found in the total number of utterances produced each month, but at a lower rate. For example, where the total number of utterances produced decreases at age 0;10 from the previous month, so does the number of utterances using multiple templates. Where the number of total utterances produced begins to consistently rise from age 1;3 onward, so does the number of utterances using multiple templates. Furthermore, at age 1;7, where the total number of utterances produced notably rises, so does the number of utterances using multiple templates.

Figure 7.11 Utterances using multiple templates from age 0;9 through age 1;7.

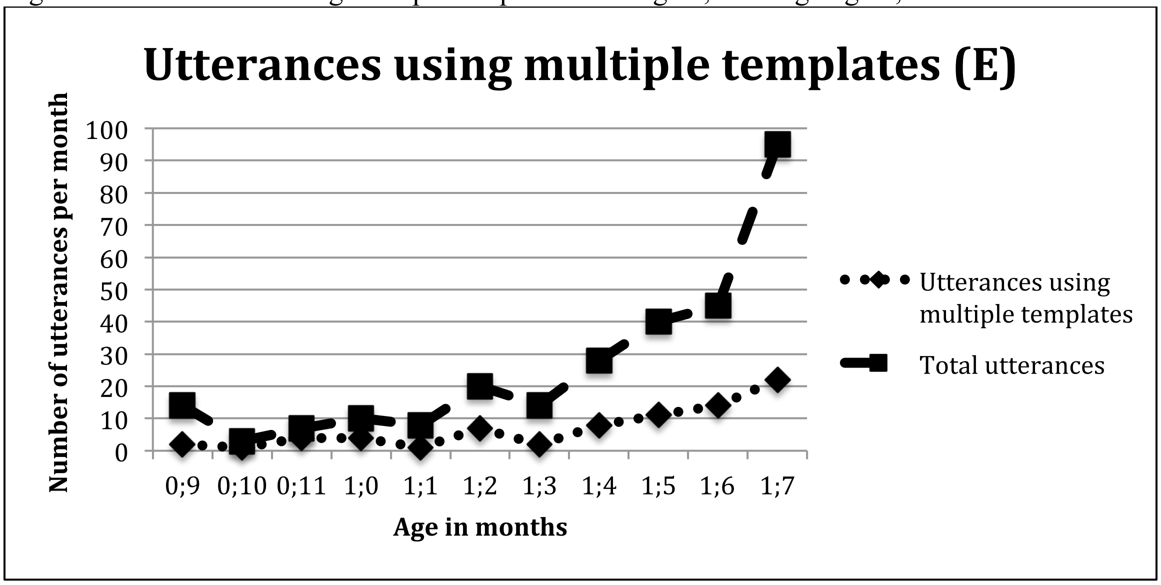


Table 7.22 Utterances exemplifying use of H-INIT and SIB-FINAL templates individually and combined.

	Age	Child form	Target word
H-INIT	0;9.8	hæ:, hæm	*hi*
	0;11.5	hæ:ɪ	*hi*
	1;3.20	hɛɪ hoʷ	*thank you*
	1;4.14	hʲu:m	*moon*
SIB-FINAL	1;0.29	dejiʃ	*there*
	1;1.9	dɪʃ, ʤɪʃ	*fish*
	1;3.20	ʧiʃ, ʤiʃ	*cheese*
	1;4.28	næʃ	*nurse*
COMBINED	1;5.11	heɪʃ	*fish*
	1;5.23	hæs	*thanks*
	1;6.18	hu:ʃ	*shoe*
	1;7.14	haʧ	*thanks*

7.3.3.3 Discussion of trends and periods of interest

While the number of utterances among E's data exhibit greater use of multiple or merged templates than the other children over their respective investigation periods, usage does not begin to consistently rise until beyond age 1;3, in the seventh month of word production. Possibly the merging of templates in Djuna's data initiates identifiable advancement of her phonotactic knowledge and capability of combining established knowledge in new ways, which allows for noteworthy expansion of the lexicon. While this phenomenon began much earlier in E's development, a comparable expansion in lexicon size is not seen until later. The rise in use of combined templates for E was accompanied by a marked increase in lexicon size. Following a temporary overall decrease in individual template use at age 1;3, the use of the LOW-HIGH V and CONS HARM templates rose briefly before all template use began to fall over the remainder of the investigation period at ages 1;6 and 1;7 (see Table 7.23). At age 1;6, 20 new words were acquired, with 45 distinct utterances; and at age 1;7, 51 new words were acquired and 95 distinct utterances were produced. By comparison, all but one of Djuna's templates decreased in usage when templates began to merge at age 1;4, and this one template (i.e., SIBILANT) was used in 28.54% of all utterances produced.

Table 7.23 Template use declines from age 1;6 to age 1;7.

Template	Age 1;6	Age 1;7
Æ	13.33%	12.63%
LOW-HIGH V	22.22%	18.95%
H-INIT	17.78%	15.79%
SIB-FINAL	17.78%	14.74%
CONS HARM	22.22%	16.84%

The schematic depiction of early phonological data is capable of rendering the process of interacting templates in continuous time. While Djuna's data provide a baseline example of schematic structure in motion, E's data show a variant example of multiple patterns interacting with increasing frequency in a developing phonological system. Charlotte's and Trevor's data exhibit a fairly low number of multiple-template utterances and stand as points of contrast for how Djuna's and E's data take shape in schematic structuring. For Charlotte, only a sprinkling of multiple-template utterances were identified; for Trevor, just over 20% of utterances at age 1;2 use multiple templates and at age 1;3, the final month of the investigation period, about 10% of utterances do. It seems likely that were the investigation period extended for Charlotte and Trevor—and Djuna, also—similarly increasing trends of multiple-template use might be seen as a more complex system comprised of possible phonotactic sequences in the ambient language develops. Another possibility, however, is that the use of multiple templates is not necessary to reach a more stable adult-like state. The use of multiple templates to produce a given word reveals different strategies for production in development. Another way to think about merging templates is that the attractive force resulting in routinized use of a given template shifts when templates begin to interact and, should conditions be sufficient, multiple-template use organizes into new templates as the detail in a phonological system becomes increasingly complex.

7.3.4 Summary

Templatic analysis for each of the three children presented here is abbreviated, intended to highlight points of contrast and comparison relative to trends found in Djuna's data. Despite this, some clear conclusions can be drawn, and trends are presented in Table 7.24. While there is an average age at which children typically begin producing words, the range of the onset of word production is broad, and rate at which children progress in lexical acquisition also varies. The sample size here is small—four children—but templates were identified in the data for all four children. Across the four children, templates differ in number, content, and rate of usage. Table 7.25 shows the percentage of utterances using templates by month for each child; months are numbered to indicate the first month of word production (Mo 1) and so on.

Table 7.24 Milestones in the acquisitional paths of Djuna (D), Charlotte (C), Trevor (T), and E.

Child	First word	50 words	How long to 50?	Temp use init.	Avg temp use	Peak temp use	Lowest temp use	Avg multi-temp use	Peak multi-temp use	Lowest multi-temp use
D	1;0	late 1;1	~2 mos	1;0	40%	1;0 (79%)	1;2 (22%)	4.07%	1;0 (14%)	1;4 (2%)
C	1;1	1;7	6 mos	1;1	64%	1;4 (92%)	1;3 (51%)	0.73%	1;6 (3%)	1;4, 1;5 (0%)
T	0;8	mid-1;1	5.5 mos	0;11	35%	1;3 (73%)	1;0 (40%)	3.50%	1;2 (23%)	1;0 (0%)
E	0;9	mid-1;4	7.5 mos	0;9	68%	1;1 (70%)	1;0 (55%)	15.44%	1;6 (24%)	1;3 (6%)

Table 7.25 Percentage of utterances using templates by month.

Child	Mo 1	Mo 2	Mo 3	Mo 4	Mo 5	Mo 6	Mo 7	Mo 8	Mo 9	Mo 10	Mo 11
D	79%	32%	22%	25%	42%	n/a	n/a	n/a	n/a	n/a	n/a
C	100%	n/a	51%	92%	88%	68%	60%	55%	n/a	n/a	n/a
T	0%	0%	0%	48%	40%	44%	71%	73%	n/a	n/a	n/a
E	71%	100%	75%	55%	70%	67%	63%	66%	66%	58%	57%

Previous research has suggested that once a child has produced 50-100 words based on item-learning, templates typically emerge as a first construction of a phonological system (Vihman, 2002). Given the early presence templates among Djuna's, Charlotte's, and E's data, it may be concluded that children do not require 50-100 words to establish templatic representation. Before so strong a conclusion can be drawn, however, data for many more children—from additional languages—need to be incorporated into analysis, and care should be taken to closely relate findings to previous templatic research.

While overall it seems that templates participate in facilitating increasing lexicon size, the relationship between templates and lexical acquisition is not black-and-white. In some cases, templates are associated with decreased lexical acquisition but a high number of distinct utterances in a given month, highlighting the role of templates in articulatory practice. In Djuna's data, however, the merging of templates is accompanied by intensified lexical acquisition. While the merging of two templates was clearly important to the development of Djuna's lexicon, and this phenomenon also seems to play an important role in E's developing phonological systems, data for Charlotte and Trevor do not so robustly exhibit this trend.

Template use on the whole apparently plays different roles in the phonological development of different children. Overall, data for Trevor show that template use was not as prevalent as early on as in Djuna's data, and templates were far more prominent in data for Djuna, Charlotte, and E than for Trevor. This fact points to templates being only part of the picture as a strategy in early phonological and lexical development, highlighting individual variation in paths of phonological acquisition.

Chapter 8: Schematic analysis

8.1 Introduction

Schema theory enriches the connection between templates in early phonological development and dynamic systems theory. This chapter provides a schematic depiction of emergent patterns in phonological representation found in data for Djuna, Charlotte, Trevor, and E, which were highlighted in the previous chapter. The schematic networks portraying Djuna's data form the center of this chapter, and data from the other children are used to illustrate (1) the utility of this theoretical framework across child data, (2) the ability of the framework to highlight the critical role of initial conditions in shaping developmental paths, and (3) the effectiveness of the framework to isolate evidence of individual differences across children during the course of development.

This chapter offers data analysis uniting templates with hierarchical schematic structures subject to continuous dynamic processes. Recall from Chapter 3 that whole-word (i.e., templatic) representational units (1) **select** for production target words whose phonetic forms contain detail in common with them and also (2) **adapt** for the production of target words that only partially share in phonological detail. While the function of templatic representation in production draws from the phonetic makeup of target words, the schema licenses instantiations of its content in production. Together conceptions of the template and the schema constrain production to the current phonological knowledge of the child, shaped to varying degree by the phonetic content of the target word.

Production patterns that had been called templates in the previous two chapters are referred to here as schemas. The patterns themselves contain the same phonological sequences. For example, the LAB-VEL template found in Djuna's data contains a non-consecutive sequence of a labial and velar consonant, with an intervening vowel and optional final vowel. The LAB-VEL schema referred to in this chapter is defined by the same pattern.

8.2 Djuna

Two templates (LABIAL-VELAR, HIGH-LOW V) described in Chapter 7, which were identified during Djuna's first month of word production, can informatively be rendered in schematic structure. Starting with the child's first patterns in use is important for letting the data show patterns as they are initiated, develop, and come to interact with other patterns. The LAB-VEL pattern is discussed first, followed by the HIGH-LOW V pattern. Subsequently, interaction between these two patterns is examined, followed by analysis of later-developing SIBILANT and A_I patterns in interaction.

8.2.1 The LABIAL-VELAR schema

The LAB-VEL schema is shaped by a labial consonant followed by a vowel and a velar consonant, with an optional final vowel: [labialC]V[velarC](V). This rendering accommodates all of the utterances that instantiate the schema during the period investigated. The schema is defined by the labial-velar consonant sequence, but each instantiation of the pattern includes a vowel between the consonants, so a vowel category is included in the schema; an optional final vowel is included to accommodate the unpredictable occurrence of a final vowel in the child forms. The child's attempts at *peek* and *Blackhawks* are highlighted here to demonstrate two processes: (1) selected use of the labial-velar pattern to target words for production whose phonetic forms contain the units specified in the schema, and (2) instantiation of the schematic labial-velar pattern in child phonetic forms. These are shown below in (1):

(1)	*target*	*peek* [p i: k]	*Blackhawks* [b l æ k h ɑ k s]
	schema	labialC V velarC (V)	labialC V velarC (V)
	child form(s)	[p/b ɪ k (a)]	[b ʌ/ɛ/æ k$^{(h)}$ (a)]

Lines are drawn from the schematic units to the segments in the child form to illustrate instantiation of the schema. The target phonetic forms for both *peek* and *Blackhawks* are provided to show that each aligns with the schematic representational sequence. Each target form includes an initial labial consonant and a second velar consonant. The target form for *peek* is a more straightforward selection for use of the schema in production since it is comprised only of an initial labial consonant followed by a vowel and a velar consonant. Selected use of the schema for the target phonetic form for *Blackhawks* may better illustrate the deployment of a whole-word schema because it contains many more phonetic elements: the initial cluster [bl] (reduced in the child form to [b]), followed by the vowel [æ] and a velar consonant [k], followed by another syllable comprised of a glottal consonant – vowel – velar consonant sequence [hɑks]. The utterances that Djuna produced for *Blackhawks* during her first month of word production are defined by the LAB-VEL schema, shown chronologically in (2):

(2) [bʌk]
[bʌk^{h}]
[bɛk^{h}a]
[bæ]
[bæk]

All but one of the forms (i.e., [bæ]) employs the LAB-VEL schema. In each form, as is expected early in development, the child reduced the initial consonant cluster to [b], omitting the more sonorous consonant [l]. The production of the first vowel varies, but this also is typical early in development. Four of the five forms hit the target-appropriate velar consonant [k], which could be aimed at either the first or the second [k]. It seems likely that the presence of two coda velar consonants in the target form increased the attraction of the schema to facilitate production of this word. The aspiration on the second and third child forms could represent the child's attempt at the onset [h] in the second syllable and may suggest that the child was targeting the medial [k] in her phonetic form. Recalling from Chapter 5 that schemas are product-oriented (Bybee, 2001: 126; Taylor, 2002), a generalized category (i.e., the schema) does not specify how it will be instantiated. This allows for creativity, which is why numerous variant—yet related—utterances are seen for a given target word.

Utterances for *peek* and *Blackhawks* illustrate instantiation in the selected use of a schematic representation. Turning to adapted use, the child produced two forms for the target word *bubble* [ba, bʌku]. The former [ba] is defined by a basic CV pattern with a target-appropriate initial consonant. The latter [bʌku] exemplifies instantiation of the LAB-VEL schema, in adapted use of the pattern, shown in (3):

(3)

target	*bubble* [bʌbɫ̩]			
schema	labialC	V	velarC	(V)
child form	[b	ʌ	k	u]

Lines are drawn from the schematic units to the segments in the child form to illustrate instantiation of the schema. The target form contains the initial labial consonant and following vowel, but does not contain the velar consonant that is part of the schema. As such, the template adapts for production of the word. Again, as noted in Chapter 3, adapted use of a pattern is indicative of the inception of a phonological system (Vihman & Velleman, 2000). As observed in Chapter 7, the velar component of the syllabic [ɫ̩], in coordination with the initial [b], may have served to attract the use of the schema.

This schema was in heavy use when Djuna was aged 1;0; in fact, 7/28 (25.00%) of utterances produced during this month were produced with the LAB-VEL pattern, followed by a significant drop the subsequent month. Following the decrease in usage, the pattern was not used to initiate the production of new words or pronunciations of old words again until age 1;4, and then use of the pattern rose only to 7/193 (3.63%) utterances. With this fluctuation of usage in view, it appears that Djuna used this early-established pattern to facilitate her earliest attempts at word production, and then she began to rely on other patterns. For example, her use of consonant harmony was at 4/37 (10.81%) at age 1;1, and the HIGH-LOW V pattern was still in use then at 5/37 (15.31%) utterances. Section 8.1.3 illustrates interaction between the LAB-VEL and HIGH-LOW V schemas very early on. Possibly this interaction gave way to a more complex developing system, subsuming the utility of the LAB-VEL template and its function of facilitating word production. Figure 8.1 depicts the LAB-VEL schema with a selection of its instantiations from Djuna's repertoire, as described above.

Figure 8.1 Schematic representation of the LAB-VEL pattern.

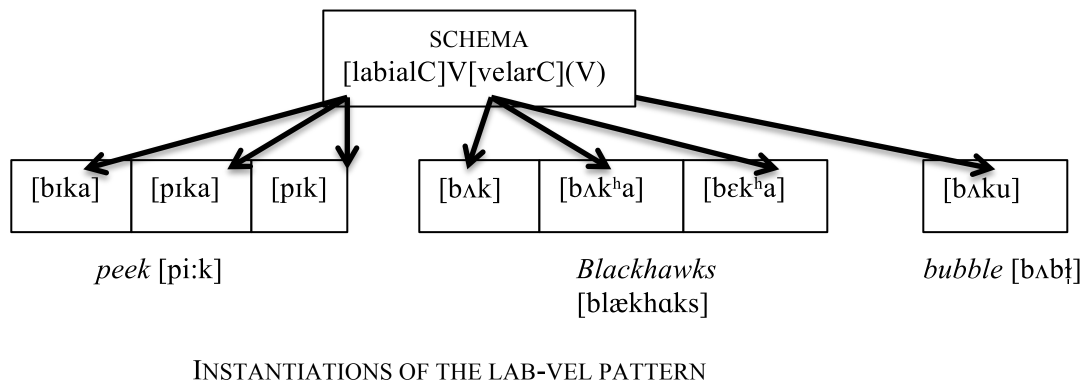
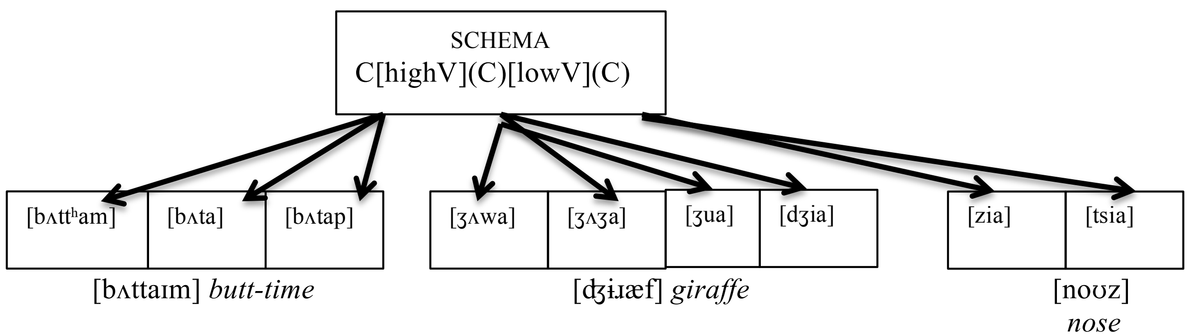


Figure 8.1 brings together data shown in (1) and (3) above to depict instantiations of the LAB-VEL schema. Utterances exhibiting selected use of the schema are shown at the left (*peek*) and center (*Blackhawks*), and adapted use is shown at the right (*bubble*). Each of these instantiations is fully sanctioned by the schema.

8.2.2 The HIGH-LOW V schema

The HIGH-LOW V schema is defined by the presence of a high vowel followed by a low vowel. Height here is defined loosely and relatively, and not in terms of absolute location in the vowel space. The schema for this pattern is proposed to be CV(C)V(C). The schema is characterized by the vowel pattern, but each instantiation occurs with an initial consonant, so the first consonant is included in the schema as obligatory. The pattern is defined as CV(C)V(C) rather than CV(C)(C)V(C), which more directly accounts for the first utterance for *butt-time* [bʌttʰam]. This designation is more general; the medial consonants in [bʌttʰam] can be considered an aspirated geminate. The absence of acoustic analysis precludes certainty on this issue. The first vowel in the schema is specified as high in that it is not specified as low, and the second vowel is low.[1] Revising the schema to accommodate these vowel specifications results in the following: C[lowV](C)[highV](C). The targets *butt-time*[2] and *giraffe* contain the units in the schema, and employment of this schema to produce these words constitutes selected use. Figure 8.2 depicts a schematic representation of the HIGH-LOW V template, exemplifying instantiations borne out of both selection and adaptation to target words for production.

Figure 8.2 Schematic representation of the HIGH-LOW V template.



INSTANTIATIONS OF THE HIGH-LOW V PATTERN

The child forms for the target *nose* [noʊz] are of interest: [zia, ʦia]. In templatic analysis, the form is explained by attributing it to adapted use of the HIGH-LOW V template. That is, the established representational pattern is used to produce a word whose target phonetic form only partially matches the template. The diphthong accounts for the high-vowel component of the pattern, but not the low vowel. In the period of time when these forms emerged, Djuna consistently avoided sonorant onset consonants,

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[1] Given the recurrence of CVCV and CVV patterns in the instantiations given in Figure 4, these patterns could be posited as mid-level schemas, potentially enriching a description of the development of schematic networks. This endeavor will be pursued as a next step in this research that attends more closely to syllable patterns.

[2] The target phonetic form for *butt-time* contains a diphthongized second vowel with a high vowel component, but the first component of the diphthong is low. The target form is considered here to be fully sanctioned by the schema.

including [n]. She was, however, capable of producing [z], the consonant in the target coda position in *nose*. In response to the challenge of sonorant onset consonants, she produced the coda consonant in the initial position and supplied the HIGH-LOW V schema to generate the rest of the utterance. It is interesting, furthermore, that the vowel pattern in these forms does not contain a vowel that is part of the target phonetic form (i.e., the diphthong [oʊ]). The pattern that appears, however, approximates the pattern seen in one of the phonetic forms for *giraffe* [dʒia], which was produced in close temporal proximity to, but preceding, utterances for *nose*. It is not clear why the child employed a pattern used to produce *giraffe* to also produce *nose*. The target phonetic forms share little in common outside of a word-final fricative. It is reasonable to suppose, however, that because she had limited phonological tools in her repertoire at the time she used a pattern, however loosely entrenched, to target the production of a word to indicate a concept she wanted to communicate. Thus, it is not that the phonetic make-up of *nose* and *giraffe* each prompted the use of the HIGH-LOW V pattern; rather, the child's current capability and, perhaps, confidence with the pattern may have impelled her to use it to produce a target that contained phonetic detail beyond her ability at the time. Furthermore, because the pattern had become routinized—that is, entrenched in her developing system—it was readily called upon. The schematic pattern, calling upon dynamic systems theory, served as an attractor—a preferred behavioral state with enhanced stability relative to other patterns in use. As such, the HIGH-LOW V schema—and also the LAB-VEL schema—attained quasi-stable representational status, initiating a temporary systematicity supporting Djuna's phonological knowledge.

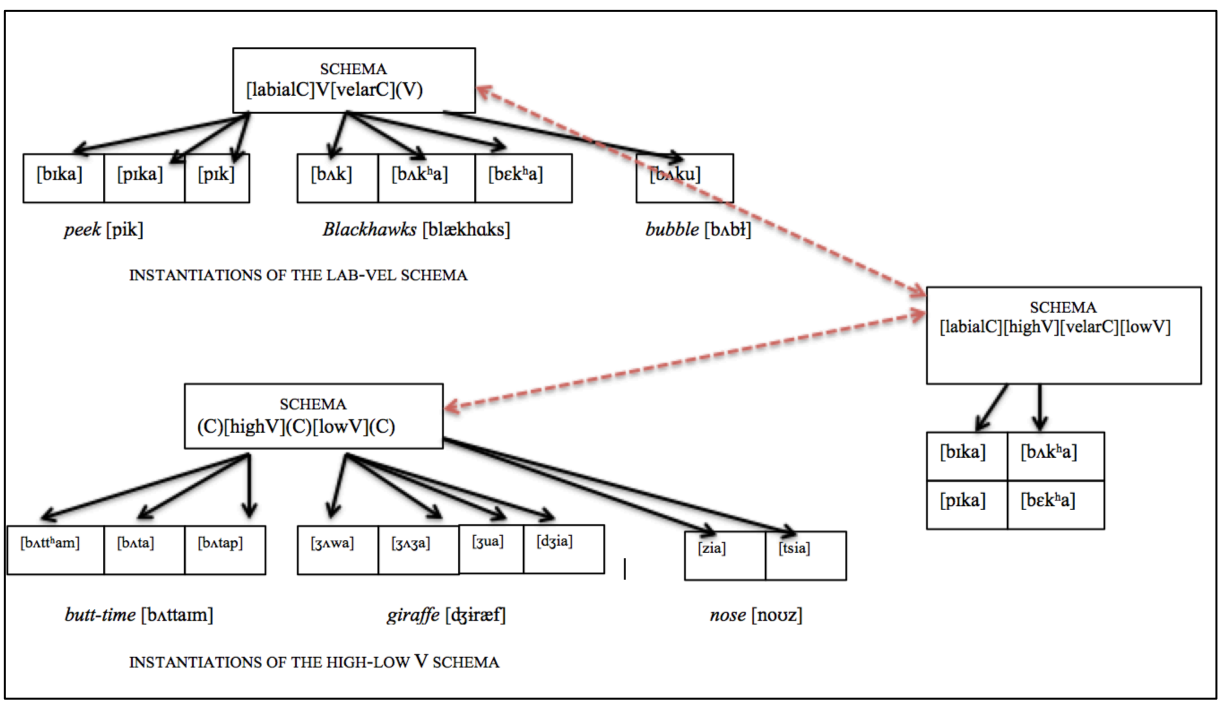
This analysis leads to an appropriate place to address the issue concerning schematic and analogical processes, introduced in Chapter 5. Djuna produced both utterances for *nose* on apparent analogy with one of her utterances for *giraffe* [dʒia]. Up to this point, no other utterance uses this vowel pattern (i.e., [ia]), and this pattern continues in use afterward. During this period of time (the first month of word production), only 12 words and 28 distinct utterances were produced. At this point, the schemas proposed here have gained in abstraction to some degree, such that they are extended for the production of somewhat phonetically dissimilar target words. However, they are not likely to exist at a very high level of abstraction because there are not many instances of usage from which the subject is able to generalize high-level patterns productive to any substantial degree.

Acquisition data in particular highlights the dynamic quality of representation. Given the very low level of abstraction at which the HIGH-LOW V schema must exist, it is not very distant in phonetic detail from its more specifically detailed instantiations. For example, *Djuna* is in one instance produced as [ʤua], which resembles the target form. It is difficult to determine whether the more abstract schematic pattern C[highV](C)[lowV](C) or a less abstract pattern in one of the other instantiations (e.g., *giraffe* [ʤia]) prompted the utterance for *Djuna* [ʤua]. Schematic structure at this point is loosely bound and in an early phase of development. The notion of a continuum based on degrees of abstraction, discussed in Chapter 5, seems feasible. However, addressing this issue in the context of unstable and rapidly changing acquisition data lends support to Langacker's (1987: 447) position that there is "no substantial difference" between the use of schema and analogy in the formation of novel expressions. At the low levels of abstraction present during the first month of word production, it is negligible whether the schema deployed in a previous utterance for *giraffe* [ʤia] or the instance of usage itself was used to produce Djuna's name. Perhaps once the representational system becomes more stable in later childhood (although acknowledging the dynamic quality of language subject to the pressures of use), it will be possible to identify a distinction between the analogical and schematic processes. An important point that is highlighted here is the ability of schema theory to capture the rich phonetic detail in production as it gradually enters into the abstract system.

8.2.3 An emerging schematic network: LAB-VEL + HIGH-LOW V

An emerging schematic network can be observed by connecting the two isolated schematic figures described above. Figure 8.3 depicts interaction between the LAB-VEL and HIGH-LOW V schemas, clarified by the chronology of Djuna's first words. Table 8.1 lists the words produced during her first month of word production, for the purpose of highlighting the order of their occurrence. The order in which Djuna's words were produced and documented suggests that the HIGH-LOW V schema emerged before the LAB-VEL schema. *Butt-time* is the first word documented, and it is an instantiation of the HIGH-LOW V schema. *Peek* appears next in the chronology, using both the HIGH-LOW VOWEL and LABIAL-VELAR schemas. Possibly the HIGH-LOW V schema emerged first at least in part owing to Djuna's name, which contains the pattern, which points to the link between perception and production. This issue is discussed in Vihman (1993), where the initial [l] in the name Laurent is demonstrated to likely be only one of other possible sources for a prominent [l]-medial pattern in the child's production repertoire. With this, the likely influence of production on directed attention to input should also be noted here: a frequent labial-velar babbling pattern was observed in the couple of weeks before Djuna began producing words.[3] Familiarity with the articulation of this pattern in babbling may have primed her to target words for production that contain this very pattern. This is an effect Vihman has described as an "articulatory filter" (1993), in which a child's early production capabilities make more salient and, thus, accessible input that is phonetically similar. The influence of early babbling sounds on the phonetic composition of first words has been shown in experimental studies (DePaolis et al. 2011; DePaolis et al. 2013; Majorano et al. 2014).

Figure 8.3 Interacting HIGH-LOW V and LAB-VEL schemas.



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[3] The LAB-VEL babbling pattern was so prominent at the onset of word production that it at first seemed that *book* was Djuna's first word. It was determined, however, that evidence for the association between the form and the referent was insufficient.

Table 8.1 Words produced during the first month, listed chronologically.

1	*butt-time*
2	*peek-a-boo*
3	*peek*
4	*pop*
5	*bubble*
6	*Blackhawks*
7	*Daddy*
8	*button*
9	*giraffe*
10	*eye*
11	*nose*
12	*glasses*

Turning again to the chronology of word production, the next words relevant in a discussion of these schemas are *Blackhawks* and *bubble*. It is proposed here that the LAB-VEL schema was abstracted away from the instantiation for *peek*, which contains both the HIGH-LOW V and LAB-VEL patterns and subsequently became productive. The LAB-VEL schema, then, was used alone to produce utterances for *Blackhawks* [bʌk, bʌkʰ, bɛkʰa, bæk] and *bubble* [bʌku] during the first month of word production.

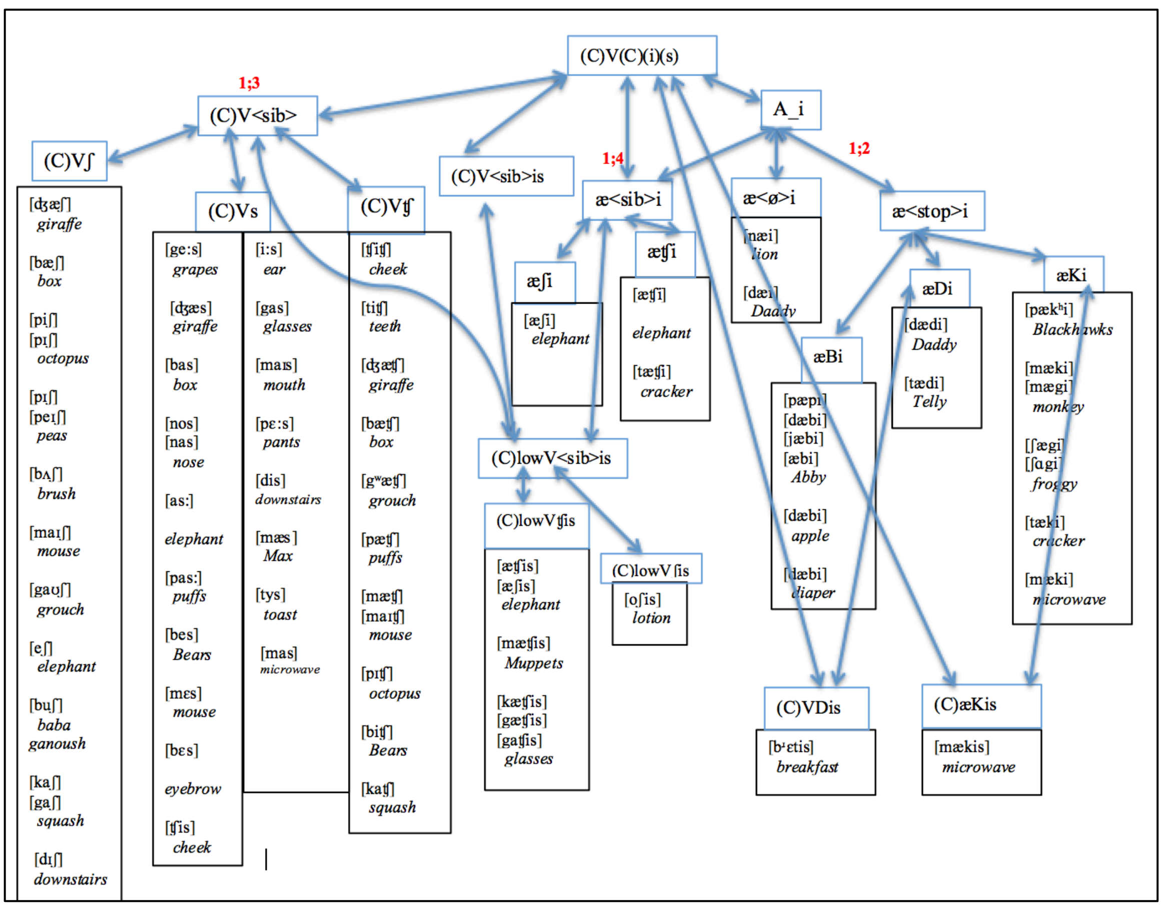
Note in Figure 8.3 that the arrows between the schemas, which represent categorizing relationships between schematic nodes, are bidirectional. This is to show that the schemas continue to influence one another and that levels of abstraction continue to shift as a function of language use. This effect is seen in instantiations of the HIGH-LOW V schema for *giraffe* (i.e., [ʒʌwa, ʒʌʒa, ʒua, ʤia]) and in instantiations for *nose* (i.e., [zia, ʦia]). Both of these words were first produced toward the end of the first month of word production, after the HIGH-LOW V schema was first used in coordination with the LAB-VEL schema to produce utterances for *Blackhawks* and *peek*. Theoretically, it could be predicted, then, that the HIGH-LOW V schema becomes more deeply entrenched in the system, increasing its attractive force as a representation called upon for production. In fact, the HIGH-LOW V schema remains in use in the second month of word production (age 1;1), in 13.51% of utterances, and the LAB-VEL schema drops out of use entirely at age 1;1, becoming unstable perhaps as a function of its loosening hold as a relevant unit in Djuna's developing system.

8.2.4 An emerging schematic network: SIBILANT + A_I patterns

In order to illustrate the capacity for the current theoretical framework to capture the turns of an increasingly complex phonological system in development, this subsection skips a few months ahead in Djuna's course of acquisition. At age 1;2, a more complex cluster of phonological patterns begins to emerge. Schema theory as a supplement to the templatic framework offers a structured way to depict not only the categorizing relationships between several different patterns and how they are realized in production, but also their interaction in time-course of development. The SIBILANT (i.e., (C)V<SIB>) and A_I patterns are described in Chapter 7 and the chronology of utterances using these patterns are displayed there. Figure 8.4 presents a schematic depiction of these patterns and proposes both the ways in which they might interact and also the levels of increasing abstraction that may be involved.

Figure 8.4 is necessarily a vertiginous appeal to the eyes. While it may be more palatable to offer a cleaner image, it is important to illustrate just how complex the early-emerging phonological system is. This figure, and those preceding it in this chapter, offer only a snapshot of Djuna's phonological system. Concurrent with the data and patterns represented in Figure 8.4, for example, are less prominent whole-word patterns, frequently used syllable patterns, and the incipient segmental representation. Keeping this in perspective sheds light on the motivation for the inclusion of the complex network seen in Figure 8.4. It makes sense to walk through the figure, moving from right to left in accordance with the chronology of schema development and the initiation of representative instantiations of each of the schemas.

Figure 8.4 Schematic network: <(C)V[sib]>, <A_i>, and sibilant-final schemas and subschemas. Capital B, D, and K, respectively, represent labial, alveolar, and velar consonants that are voiced or voiceless. Approximate age at the time of the initiation of a schema is included for reference: æ <ø>i and æ<stop>i, 1;2; (C)V<sib>, 1;3; æ<sib>i, 1;4.



The A_ɪ schema was first observed at age 1;2 and is associated with three subschemas, including one in which a sibilant segment occurs between the two vowels (i.e., A<sib>i), one in which nothing intervenes between the vowels (i.e., A<ø>i), and one in which a stop consonant occurs between the vowels (i.e., A<stop>i). The basic and more abstract A_I schema emerged at age 1;2 (i.e., second month of word production). During this time, the null and stop subschemas also emerged. The subschema containing an intervocalic sibilant did not emerge until age 1;4. Following the arrows from the schema to schema, one finds specification, for example, of the A<STOP>I schema, with both voiced and unvoiced variants of intervocalic [B], [D], and [K]. An arrow traces a path from the AKI schema to a schema defined as (C)AKIS. A second arrow reaches this schema from a more abstract and vaguely defined schema: (C)V(C)(I)(S). This schema, of greater abstraction in the hierarchical organization, connects to five other schemas. Each of those schemas specifies this schema in different ways; these schemas include (C)V<SIB>, (C)V<SIB>IS, A<SIB>I, CVDIS, A_I. Recall that the arrows between schemas are bidirectional. When any of these schemas is employed to produce a given utterance, the pattern is reinforced, rendering it a more stable unit in the system.

At the left-hand side of the figure is the SIBILANT schema, containing an optional initial consonant followed by a vowel, preceding the sibilant consonant. At a lower level of abstraction are three subschemas, one that specifies the sibilant as [ʃ], one that specifies the sibilant as [s], and one that specifies the affricate [ʧ]. The general SIBILANT schema and its subschemas began to emerge when Djuna was aged 1;3. It is acknowledged here that what have been classified as subschemas of the SIBILANT schema may actually be motoric variants of one another due to the immature articulatory abilities of the child. The subschemas are nevertheless depicted here, in accordance with the child's utterances as documented in a detailed rendering of the development of the child's segmental knowledge from early whole-word patterns.

It is notable that the sibilant A_I subschema (e.g., Æ<SIB>I) does not emerge in the data during the same period as the other two subschemas, and in fact does not appear until after the sibilant structures begin to emerge, at about age 1;4. This, along with the apparent merging of the two patterns, lends credence to a proposal that this subschema emerged out of the two schemas. If this is the case, then there may also be a more abstract level that connects these two schemas. One possibility for this more abstract schema is (C)V(C)I(<SIB>)(I)(S).[4] This pattern accounts for each of the patterns that sit both above and below (in terms of greater and lesser abstraction), the A<SIB>I schema. The fate of increasingly abstract whole-word schemas is not yet clear; possibly some lose their utility and disappear. Possibly they give way to segmental representation hinging on the acquisition of finer-detailed phonotactic and phonetic information. Another possibility is that some less frequent phonotactic sequences maintain their representational status as a larger unit. Vihman and Croft (2007: 284) argue that whole-word representation may be present in adult phonological systems. It will be important to carry a study of this theoretical model further into development in order to address these questions more thoroughly.

A schematic network, as shown in Figures 8.3 and 8.4, offers a depiction of the interaction of multiple whole-word representational patterns; it also casts new light on the complex nature of a phonological system in the earliest and seemingly unsystematic stages of development. A phonological system, of course, involves more than a sequence of consonants and vowels, as is represented in the figures shown here. Prosodic and more richly detailed phonetic information should also be part of this picture. Again, the

[4] The increasing optionality of elements in the more abstract patterns produces a challenge that requires further study. It introduces the question of the nature of the evolving representation of phonotactic information and when and how segmental knowledge begins to emerge.

schematic networks are relatively neatly depicted—even in Figure 8.4, in that only the patterns relevant for discussion are represented in the schematic figures, but there is far more going on as the phonological system develops. Indeed there are many words that do not use the templates described here, or use templates at all. Possibly this is due to the use of prosodic templates or the simultaneous development of segmental knowledge.

From the perspective of dynamic systems theory, this continuously developing phonological knowledge interacts online as the child experiences and uses language, and the details of language vary in frequency of usage and phonological environment such that the child's knowledge is subject to constant small shifts reflected in the larger developing system (Gershkoff-Stowe & Thelen, 2004; Thelen & Smith, 1994). At the point during which some of the data presented here emerge, Djuna's lexicon contains more than 200 words, with phonological patterns that interact both directly and indirectly with the patterns presented here. As such, a schematic representation of Djuna's phonological system is likely to be quite dense and richly detailed. The schematic network presented here offers a means of illustrating the possible structures in the process of emerging and does so by factoring in the time course of development.

The optionality indicated by the parentheses is a feature of this theoretical model that will be fine-tuned as additional data contribute to its development, and as it is applied later into the phonological acquisition process. For example, if an utterance shaped by the (C)V(C)(I)(S) schema, at the top of the figure, included only the obligatory unit (that without parentheses), it would include only [s]. None of the utterances occur in this form, so there must be some constraint foisting the requirement upon an instantiation of a schema that it contain a certain number or combination of units available in the schema.

A possible solution for this issue is that, at least for English, a foot serves as a prosodic schema from which subschemas including more specific detail are instantiated. Juszczyk et al. (1993) showed that by age 0;9 infants acquiring English exhibit sensitivity to stress patterns in the speech stream. Specifically, infants are attentive to the prosodic structure of words, which facilitates word segmentation and, subsequently, the development of the lexicon. This line of thought can be carried out to propose that early attention to the prosodic structure of words, which guides an infant to begin segmenting words, leads to the extraction of word-shaped phonotactic patterns represented as schemas. With this, the schematic foot constrains production to be comprised of at least one syllable and no more than two, which prevents utterances defined by only a single segment (e.g., [s]).

8.3 Charlotte: V-INIT SCHEMAS

This section renders Charlotte's emerging V-INIT patterns and sub-patterns in a schematic network. Among Charlotte's first words at age 1;1, 3/7 of them took a V-INIT shape; each of the three utterances were selected by the schema (i.e., matching the contents of the schema). Putting in perspective the prominence of this pattern in Charlotte's development, Table 8.2 shows the percentage of utterances that instantiate the schema for each month under investigation.

Table 8.2. Percentage of utterances using V-init schema by month. (Note: No data were documented for age 1;2.)

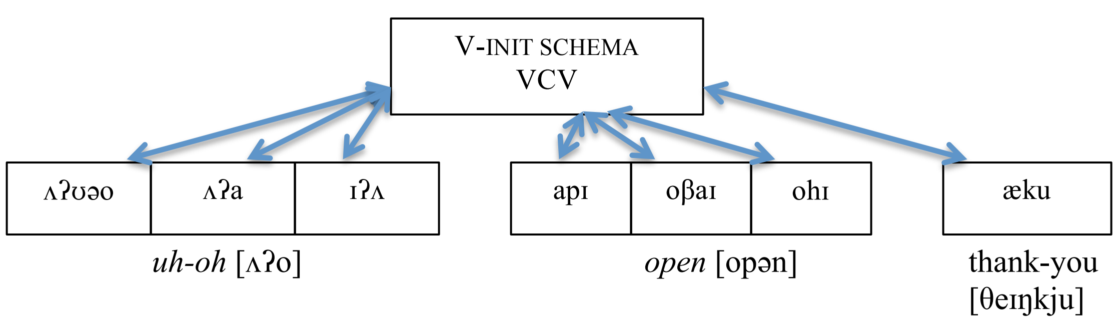
Age	% V-INIT utterances
1;1	42.86%
1;3	31.71%
1;4	60.87%
1;5	70.00%
1;6	48.72%
1;7	28.79%
1;8	19.49%

Increasing use of the schema is seen through age 1;5, after which the pattern becomes less stable in the system and begins to fall out of use.

Recall that Vihman and Velleman (2000) point to the inception of an abstract system in the adapted use of a representational pattern (i.e., a pattern is extended for the production of a word whose phonetic contents only partially match). The first adapted use of the pattern is seen at age 1;3 in an utterance for *thank-you* [æku]. The 12 utterances faithfully employing the pattern are nonetheless important. In fact, they play the vital role of entrenching the pattern into a relatively stable unit in Charlotte's developing system. By way of this process, the pattern is extended for the production of words whose target phonetic forms deviate from the schema. Because it is at age 1;3 that the schema can be said to gain in degree of abstraction, data presented to illustrate developing schematic networks for Charlotte begin at this point.

Two figures illustrate the development of this schematic network and the lexical items affected. Figure 8.5 offers a simple schematic rendering of data at age 1;3, and Figure 8.6 offers a more complex network when subschemas began to split off into variant patterns and expanded hierarchical organization begins to be seen.

Figure 8.5 Instantiations of the V-INIT schema at age 1;3.



SELECTED INSTANTIATIONS OF THE V-INIT PATTERN

The V-INIT schema is proposed as an obligatory VCV sequence, with the potential for additional segments to occur in its instantiations. Figure 8.5 shows utterances for *uh-oh* and *open*, which exemplify selected use of the V-INIT schema, and an utterance for *thank-you*, which is the first documented adapted use of the pattern. While this analysis proposes the use of a schematic V-INIT template to produce the utterance for *thank-you* shown here (i.e., [æku]), it is acknowledged that the child form could also be explained by initial consonant omission. Utterances instantiated by V-INIT by way of initial consonant omission (Table 8.3) have in common a target initial voiceless consonant, except for *what's that* with an initial voiced [w], but the target forms have little else in common. A closer look at the forms produced during this period, which are not subject to this schema, is required to draw firmer conclusions about the relationship among the child forms and target words associated with the schema. Charlotte accurately produced voiceless initial consonants, both where it was target-appropriate (e.g., *thank-you* [tekju]) and where it was not (e.g., *please* [həis]). It is not clear why *thank-you* would have been subject to something like an initial consonant omission rule, particularly when she also produces a form like [tekju] for it, except that a V-INIT schema guided production behavior. With this, and the extension of the strategy to target an increasing number of words for production using this pattern, a V-INIT schema seems to guide production from age 1;3 – 1;8.

Table 8.3 Utterances exhibiting initial consonant omission, age 1;4 – 1;8.

Age	Target word	Target initial consonant	Child forms
1;7	*cookie*	[k]	[ʌkis, aki, ʊki]
1;7	*tiger*	[t]	[əβjeə]
1;7	*hello*	[h]	[æjʌ]
1;7, 1;8	*what's that*	[w]	[ɪs dæ, ʌ ðæ]
1;7, 1;8, 1;8	*please*	[p]	[ɛ:, is, eis]

Charlotte's data exhibit vowel-initial child forms which, in relationship to their target forms, split into the one pattern exhibiting what in a rule-based framework would be initial consonant omission (as described above) and another pattern exhibiting vowel-epenthesis word-initially, relative to the target form. Table 8.4 shows utterances produced as the latter strategy came into use. Some of the target forms have a CV shape, and others have a CVCV shape. In most representative utterances, Charlotte maintains the target prosodic shape and then epenthesizes an initial vowel. It is possible, in many cases (e.g., *cookie*, *book*), that the child intended to produce an indefinite article preceding the target word, resulting in something like [ɪbʌk] (a book), but this cannot be confirmed.

Table 8.4 Utterances exhibiting word-initial vowel-epenthesis.

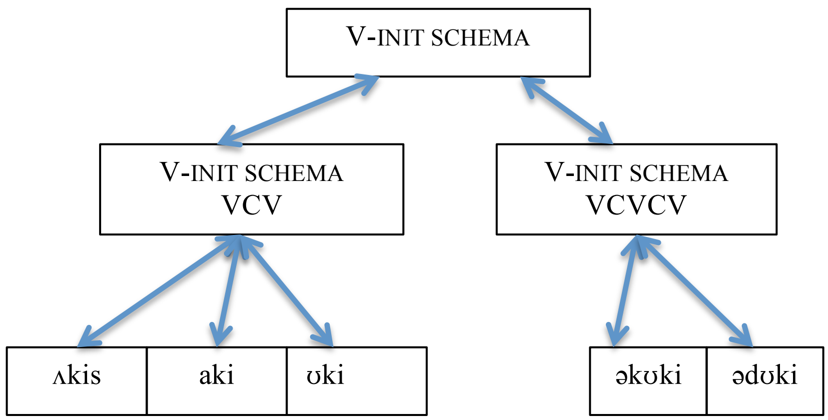
Age	Target word	Target form	Child form
1;6	*bee*	[bi:]	[əʒi]
1;6	*book*	[bʊk]	[ɪbʌk]
1;7	*cookie*	[kʊki]	[əkʊki, adʊki]
1;7	*Benny*	[bɛni]	[əbæ]
1;7	*down*	[daʊn]	[ɪdaʊn]
1;7	*help*	[hɛlp]	[əha]

As is seen in Table 8.3, Charlotte targeted *cookie* with the V-INIT schema. Her utterances for *cookie* illustrate her experimentation with the word and the employment of different strategies to produce it. Her first utterance was an accurate CVCV shape: [kʊki]. Thereafter, Charlotte produced several VCVC variants. In fact, she used a CVCV pattern for all utterances for *cookie* except in the instantiation of the V-INIT schema. These are seen in (4):

(4) [kʊki]
[tʊki]
[dʊki]
[gʊki]
[gaki]
[bʊki]
[gʌji]
[gʊgi]

Again, among utterances employing V-INIT, sometimes the initial consonant is omitted; sometimes a vowel is epenthesized word-initially. Figure 8.6 shows an abbreviated network of utterances for *cookie*, which illustrates these two V-INIT strategies, defined by syllable shape: VCV (as in Figure 8.5) and VCVCV. Utterances in Figure 8.6 were produced when Charlotte was aged 1;7, during a month of particularly active experimentation with this word.

Figure 8.6 Instantiations of the V-INIT schema for *cookie* at age 1;7.



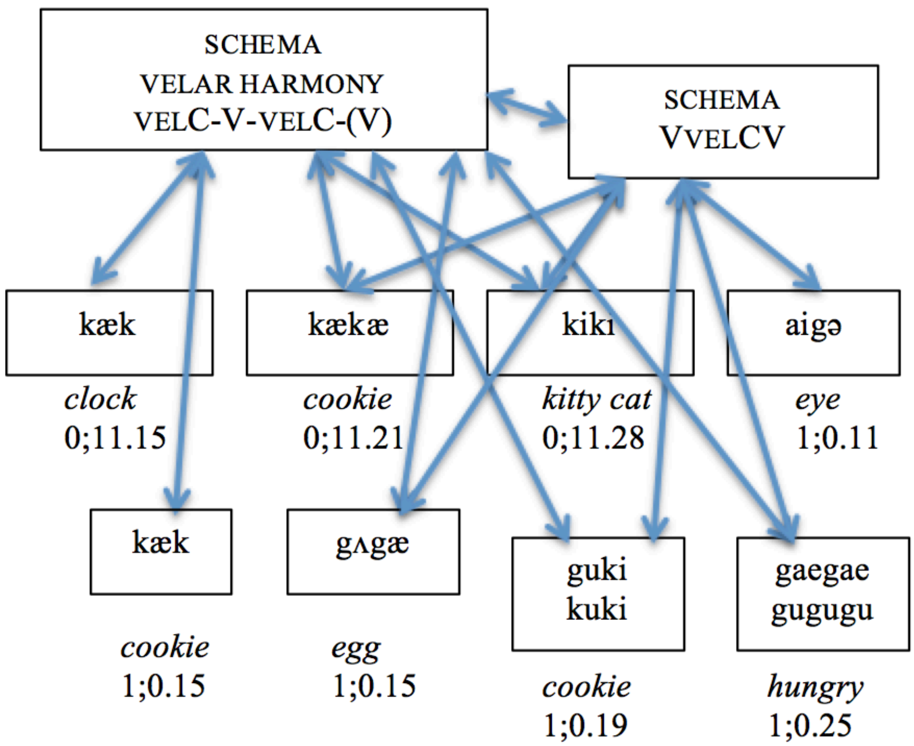
SELECTED INSTANTIATIONS OF THE V-INIT PATTERN FOR *COOKIE*

Schema theory, in this way, offers a clear way to account for these two production strategies as instantiating schemas of a more basic vowel-initial schematic shape. By following the chronology of utterances, one can trace the original V-INIT pattern as a split between associated VCV and VCVCV incarnations develops and deepens. Among Charlotte's early data are many utterances targeting *uh-oh*, *again*, and *open*. Perhaps the frequency with which she began utterances vowel-initially contributed to the stabilization and extension of the pattern to target other words for production. It also seems likely, given the relevance of syllable shape in the child's phonetic forms, that prosodic structure also factors in. Stepping back for a broader view, it is important to remember that while this pattern played a prominent role in Charlotte's developing system, so did other patterns, at least some of which likely exerted some influence on V-INIT.

8.4 Trevor: Velar-based schemas

Related velar harmony (VEL HARM) and VVELCV schemas were identified among Trevor's data. The temporary increasing use of each of these patterns offers a snapshot of fleeting phonological organization along Trevor's path of acquisition. The data offer support for the utility of the schematic model by effectively depicting emergent phonological patterns subject to the property of self-organization, and developing, interacting, and, in some cases, dissolving in real time. Because the two patterns presented here are closely connected, it is important to employ the chronology of utterances to determine whether the two patterns first developed independently and then merged or whether both patterns split off from a higher-level pattern that encapsulated them both. If the former, placing the data in schematic structure can help determine which schema formed first, revealing something about the organization of the phonological system at the time. Figure 8.7 illustrates a schematic network depicting data collected when Trevor was aged between 0;11 and 1;0, reflecting the initiation of each the VEL HARM and VVELCV schemas. With the first utterance for *clock* [kæk] at age 0;11.15, a velar harmony schema enters into development. Importantly, this utterance reflects selected use of the schema. Recalling from Vihman and Velleman (2000) that it is adapted use of a pattern that indicates the entry of a unit into a child's abstract phonological system, this schema is very low-level until the first adapted use for *egg* [gʌgæ] at age 1;0.15 is seen. The age at which each utterance was produced is provided for ease of reference.

Figure 8.7 Instantiations of the VEL HARM and VVELCV schemas at ages 0;11 and 1;0.



A VEL HARM schema, in which the VVELCV pattern can also be seen, is proposed to have developed first, after which the VVELCV pattern peeled away. At this point, first utterances using both patterns are seen: *cookie* [kækæ] (age 0;11.21), *kitty cat* [kiki] (age 0;11.28). After this point, [aigə] is produced for *eye* (age 1;0.11), using only the VVELCV schema, which suggests that it has become its own representational unit separate from the VEL HARM schema. After the VVELCV schema split off, Trevor continued to produce words sometimes using only the VEL HARM schema (e.g., *cookie* [kæk], age 1;0.15) and both together (e.g. *cookie* [guki, kuki], age 1;0.19). For reference, Table 8.5 shows the percentage of utterances using each of the templates in each month of the period of investigation.

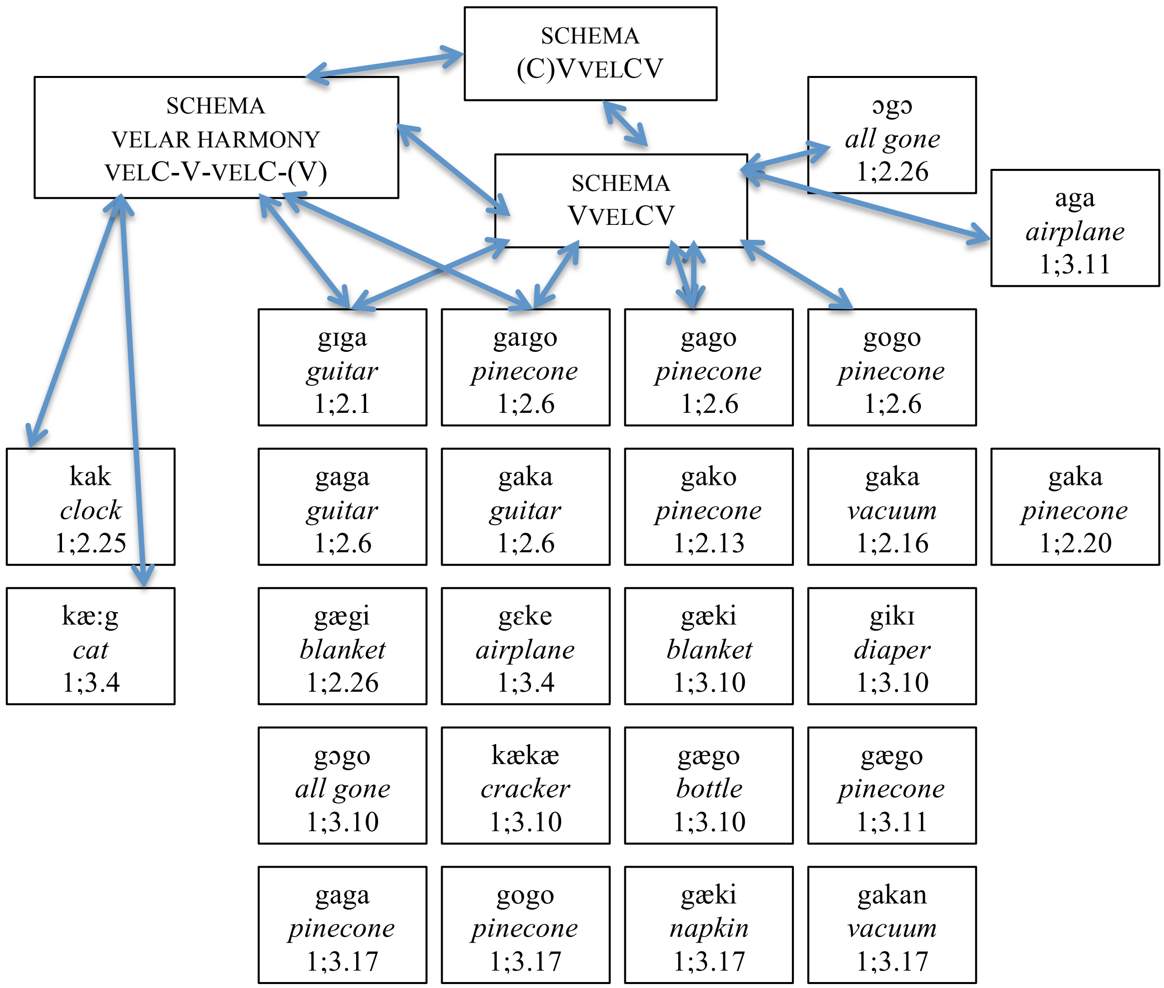
Table 8.5 Percentage of utterances using the VEL HARM and VVELCV patterns by month.

Age	VEL HARM	VVELCV
0;11	13.04%	0.00%
1;0	9.23%	7.69%
1;1	7.48%	3.74%
1;2	16.07%	17.86%
1;3	16.51%	19.27%

After a decrease at age 1;1, the use of both patterns increases to the end of the investigation period. It is reasonable to suggest that the patterns reinforced each other whenever the child employed them in production. Analysis has not been conducted past this point, so it is not clear in which direction the trend travels after age 1;3.

Both schemas were quite prominent at age 1;2 and 1;3, affecting the pronunciation of a spate of words and resulting in variant productions for most of these words. Both selected use (e.g., *cracker* [kækæ]) and adapted use (e.g., *pinecone* [gaɪgo]) of the schemas were observed. Figure 8.8 provides a schematic network showing relationships between selected utterances produced at age 1;2 and 1;3. In the interest of clarity, arrows connecting both schemas to the majority of utterances only physically connect to the top row, but these arrows should be understood to connect to the entire block of utterances. Two utterances are shown to exemplify only the VEL HARM schema: *clock* [kæk] and *cat* [kæ:t]; and two utterances exemplify only the VVELCV schema: *all gone* [ɔgɔ] and *airplane* [aga]. The remaining utterances were observed to use both schemas simultaneously. A higher-level schema connecting the VEL HARM and VVELCV schemas is proposed as (C)VVELCV. This would allow for other creative instantiations of this more general schema. It seems likely that a CVCV schema exists at a higher level, which (C)VVELCV instantiates.

Figure 8.8 Instantiations of the VEL HARM and VVELCV schemas at ages 1;2 and 1;3.



It is important to be mindful while looking at this figure that other utterances with other shapes were produced during the same period of time. Rendered schematically, these would form other networks connecting either by way of segmental or prosodic patterning. Additionally, one need not look long to see (1) the preponderance of homonymous forms used across lexical items (e.g., see utterances for *vacuum*, *pinecone*, and *guitar*) and (2) the remarkable similarity between all of the forms in the figure.

During the period represented in Figure 8.8 (i.e., ages 1;2 and 1;3), the VEL HARM and VVELCV patterns seemed to be highly stable and deeply entrenched in the system. While analysis has not yet been undertaken past this point, it is clear that the pattern was not as prominent (i.e., not as stable) prior to this period. This point supports an argument for whole-word patterns of fleeting stability as representational units in the early stages of phonological development. Furthermore, a schematic network depicting the effect shown in Figure 8.8 aptly emphasizes the reality of whole-word patterns in early child data and highlights the importance of initial conditions as a phonological system develops.

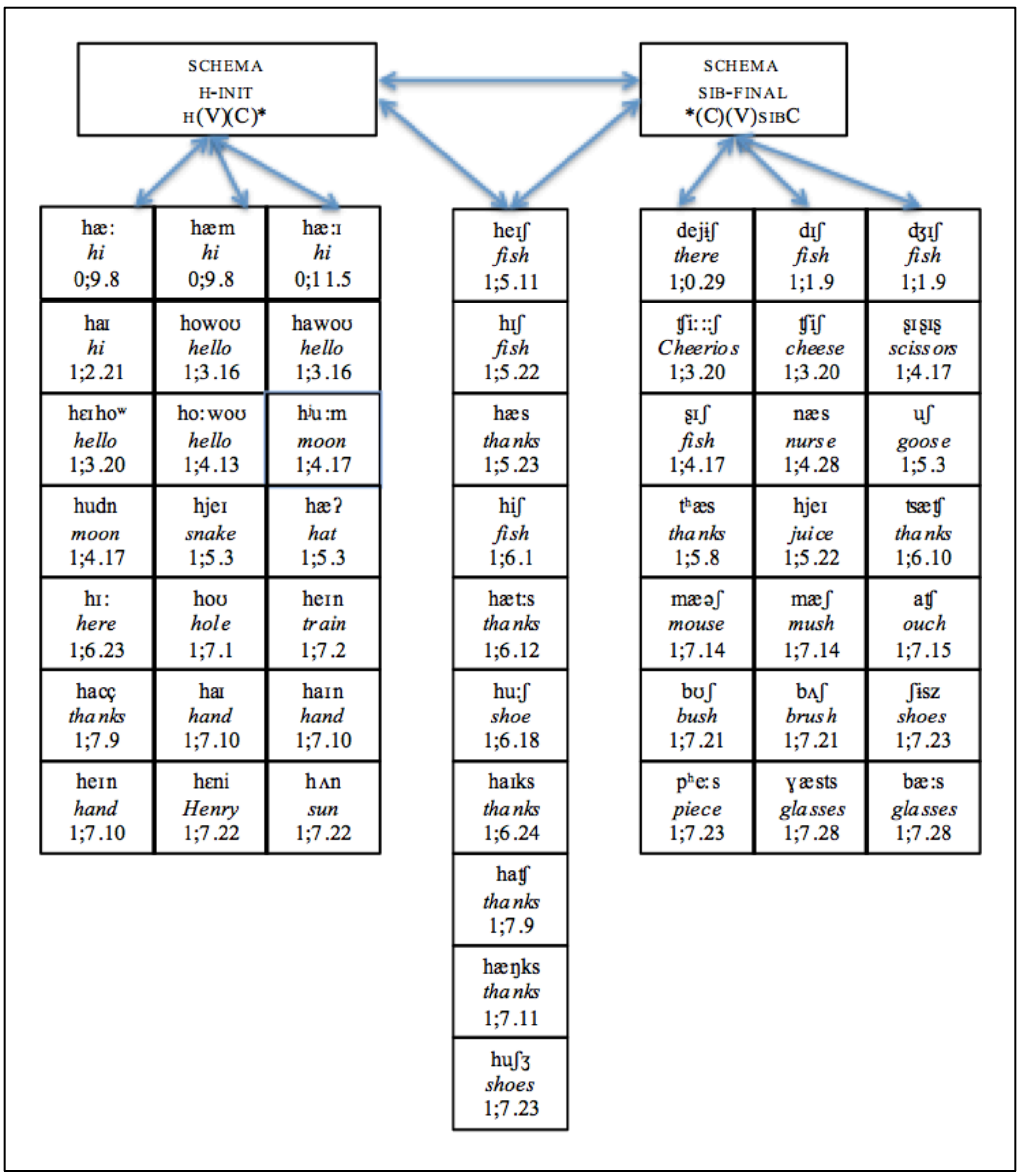
8.5 E: Multiple-schema use—H-INIT and SIB-FINAL schemas

While Djuna's data provide a baseline example of schematic structure in motion, E's data show how a phonological system develops when multiple patterns are used in combination with increasing frequency early in word production. Charlotte's and Trevor's data exhibit a fairly low number of multiple-schema utterances and stand as points of contrast for how Djuna's and E's data take shape in schematic structuring. Schematic networks for the simultaneous employment of the H-INIT and SIB-FINAL schemas are provided and discussed in this section. Additionally, to illustrate interconnectivity with other patterns in the system, a broader network is provided, which depicts each of these schemas as they connect to other prevalent patterns.

Multiple-schema use in general occurred early in the E's production (age 0;9), and substantially settles into a strategy between age 1;3 and 1;4, increasing thereafter to the end of the investigation period at age 1;7. Both the H-INIT and SIB-FINAL schemas trickle into usage, but substantially enough to constitute their identification as schemas.

Utterances using H-INIT were first observed when E was aged 0;9.8, and utterances using SIB-FINAL were first observed at age 1;0.29. The first occurrence of an utterance using both patterns occurs at age 1;5.11. Only a small sampling of target words (most frequently *fish* and *thanks*) was targeted by both schemas, but this resulted in different pronunciations, and the escalating use of the schemas together is of interest. Figure 8.9 shows the emergence of each of the two schemas individually and in combination.

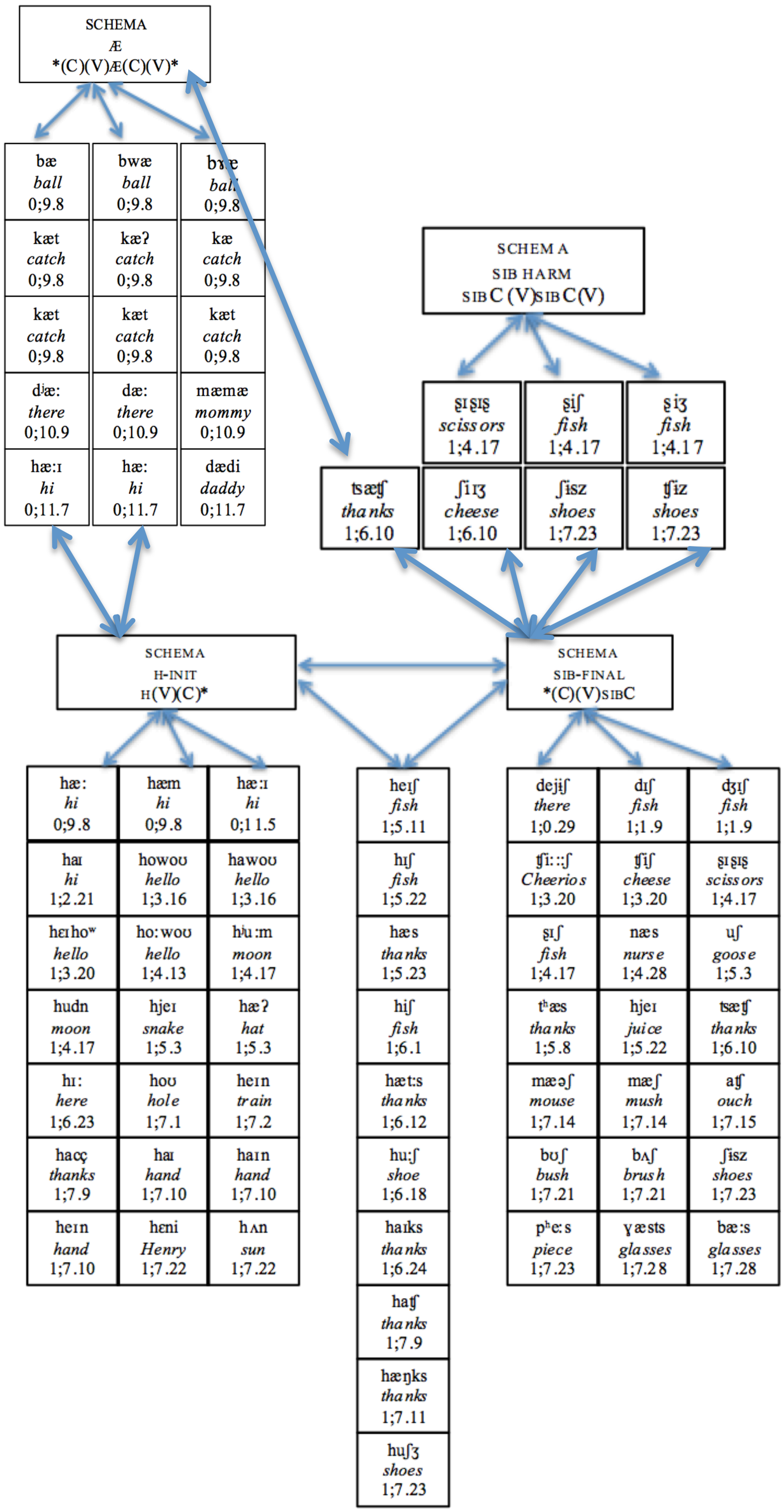
Figure 8.9 Instantiations of the H-INIT and SIB-FINAL schemas.



Each H-INIT and SIB-FINAL emerged independently, then first occurred in combination in an utterance at age 1;5.11. The H-INIT schema is defined as H(V)(C)*: initial [h], followed by an optional vowel and consonant. The asterisk indicates variable combination of vowels and consonants following the [h]. The SIB-FINAL schema is defined as *(C)(V)SIBC, following the same notational scheme. A schematic foot likely guides the instantiation of the segment-based schemas in accordance with English prosody. The arrows between a schema and a block of instantiations are intended to apply to the entire block; for the sake of keeping the image clean and easier to read, arrows are drawn only to the top row in a block. Arrows at each end of the lines connecting schemas again indicate bidirectionality in the relationship between schematic categories. As a consequence of this relationship, the production of utterances exploiting the relationship between the schemas reinforces each independent schematic structure, stabilizing its status in the system. Thus, utterances using only one of the two schemas and utterances using both schemas all participate in the stabilization of the common pattern.

Figure 8.10 allows us to bring the focus back for a broader view, depicting the H-INIT and SIB-FINAL schemas in connection with other prevalent schemas, namely AE and SIBILANT HARMONY. Because E's data provide an abundance of utterances instantiating multiple schemas at once, it is possible to construct a set of schematic networks illustrating a broader view of the system than is possible when depicting the interaction between two prominent schemas as in Djuna's lexical development (see Figure 8.4) when patterns and their interconnections had become more complex. This feature of E's developing system allows for the informative inclusion of age with each utterance.

Figure 8.10 Networks connecting the Æ, SIB HARM, H-INIT, and SIB-FINAL schemas.



8.6 Summary

The focus in this chapter is on the development of schemas in Djuna's data and their representation in schematic networks. Schematic networks showing data from the other three children are presented minimally for the purpose of highlighting (1) the utility of employing schema theory in templatic analysis, (2) the fact of individual differences when data across children are examined in close focus, and (3) the importance of the role of initial conditions in the developmental course of a individual child's phonological system.

Djuna's data provides two early-emerging schemas (LAB-VEL and HIGH-LOW V) that can be clearly depicted in simple networks. These two patterns are fleetingly used in combination to produce words early on, enabling the construction of a simple network. The documented chronology of utterances allows for the development of each schema and their combination to be traced. Later in her development two different schemas, which became prominent in her system, began to be used in combination. The utterances that result, along with the variety of systematic sub-patterns found therein, can be informatively rendered in a complex schematic network.

Charlotte's data bring to analysis a different set of schemas and developing systematicity. By following the chronology of utterances in her data set it is possible to construct a schematic network in which a prominent V-INIT schema splits off into two related patterns. Exhibiting a somewhat different behavior, among Trevor's data are instantiations of two closely related velar-based schemas. After the VVELCV schema peels away from the VEL HARM schema, the two continue to reinforce one another and also independently instantiate utterances. Finally, E’s data enable a richly detailed view of multiple interconnecting schemas, employed in various combinations.

When conceptualizing degrees of abstraction in the hierarchical schematic networks presented here, it is important to bear in mind that these degrees reflect more than the variable abstraction of units within the phonological system. Also reflected is the transition of practiced phonetic detail into low levels of abstraction. Indeed this process characterizes how a child’s prelinguistic vocalization patterns influence the phonetic shapes of first words and the formation of a phonological system.

Chapter 9: Discussion and conclusion

9.1 Overview of the dissertation and the concluding chapter

The period of phonological development at the onset of word production consistently elicits noisy data that present a challenge to current theoretical frameworks. The challenge arises from attempts at an inclusive account of linguistic processes and representation in both children and adults. Child forms commonly exhibit processes rarely found in adult language, like velar fronting, metathesis, and consonant harmony (Rose & Inkelas, 2011). In addition, particularly at the onset of word production, an individual child's repertoire may contain variant forms for a single target word and phonetic forms that defy segmental analysis (Vihman & Croft, 2007). Child data are replete with forms that exhibit little systematicity, particularly when viewed from nativist perspectives focused on relating segments or features between child and adult target phonetic forms (e.g., Chomsky, 1980; Jakobson, 1941/1968; Smith, 1973).

An approach that can effectively provide some resolve for these issues is found in the templatic approach to early-developing representation (Vihman & Croft, 2007). Whole-word representational patterns have been shown to emerge idiosyncratically in a child's phonological system, defying nativist inscription. Emergentist platforms, however, readily account for these phenomena. They assign domain-general cognitive processes to the task of guiding the acquisition of phonological knowledge (e.g., Bybee, 2001; Stemberger & Bernhardt, 1999). In a dynamic systems approach, in particular, a system is impelled by the properties of self-organization, in which softly assembled variables stabilize as attractors and reconfigure in response to a variable shifting in behavioral strength (Thelen & Smith, 1994). In this way, language-specific structure comes together by way of language use.

The present work unites a whole-word approach to phonological acquisition (i.e., phonological templates) with schema theory (Langacker, 1987; Taylor, 2002) and dynamic systems theory (Thelen & Smith, 1994) as emergentist models of language development. The intent in this work is to demonstrate a theoretical framework capable of describing the noisy phonological configurations present in early child data and, furthermore, of explaining how early tenuous systematicity reaches a more stable state. At heart, this work is a study of developing phonological knowledge, reconceptualizing what has been thought of as representation as continuously interacting processes dependent on temporal information.

The templatic framework (Chapter 3) demonstrates a means of locating emerging systematicity in early child data. This approach defines phonological representation in early development as shaped by the whole word rather than by segments or features, and describes how familiar and established phonotactic patterns are used to target phonetically related words for production. The templatic approach inscribes development within an emergentist model of language, aptly captured by the properties of dynamic systems theory (Chapter 4). Integrating schema theory (Chapter 5) within this model facilitates an account of how schematic whole-word-shaped behavioral patterns reap variant but phonologically related utterances. Schemas emerge as generalizations over instances of usage, guided by the child's own production patterns and associated attention to detail in the ambient language. The patterns apparent in utterances instantiated by a particular schema reflect emerging systematicity in a child's phonological system, which tends to be marked by some degree of idiosyncrasy.

The period of phonological acquisition addressed in this research is critical for gaining a meaningful understanding of how a phonological system develops. Data collected at the onset of word production expose idiosyncratic paths of development and emphasize the importance of initial conditions. A child's phonological tools and capacities present at the onset of word production, and before that in prelinguistic vocalizations, impact the path along which a child develops phonological categories. Conclusions about templatic behavior in the four children studied in this research appear in Section 9.2.1, and conclusions drawn from the schematic depiction of their developing systems appear in Section 9.2.2. Limitations and future directions are discussed in Section 9.3. This research lays the groundwork for numerous possibilities to test and expand on in future work. The chapter concludes with a brief description of some of these possibilities.

9.2 Conclusions and discussion

9.2.1 Templates in early phonological development

The developing phonological systems of four children acquiring American English form the foundation of this research. For each child, production data collected at the onset of word production were examined for evidence of templatic behavior, and templates were identified in the data of each child. General observations are listed below:

1) In accordance with criteria laid out in Chapter 3, **each child's data reflect the use of templates** in word production.

2) Differences in rates of development and **template use necessitated different ranges for the investigation of each child**. Analysis aimed to capture the initiation of template use and important periods of change in templatic behavior. The relevant investigation period for each child is listed below.

- *Djuna*: age 1;0 – 1;4
- *Charlotte*: age 1;1 – 1;8
- *Trevor*: age 0;8 – 1;3
- *E*: age 0;9 – 1;7

3) **Each child used a different set of templates**. While the most prominent are listed below, less prominent patterns were also identified.

- *Djuna*: HIGH-LOW V, LAB-VEL, SIBILANT, A_I
- *Charlotte*: V-INIT, H-INIT, CONS HARM
- *Trevor*: VVELCV, VALVCV, CONS HARM—prominent use of VEL HARM and ALV HARM
- *E*: Æ, H-INIT, SIB-FINAL, CONS HARM

4) **More than one template was observed among each child's data** at any given point in time during the investigation period, although typically one at a time was most prominent.

5) Where the same name was given to a template across children (e.g., H-INIT in Charlotte and E—see Chapters 7 and 8), **template use differed in behavior or rate of usage**. Consonant harmony patterns offer another example, a study of which may contribute to the seminal study in Vihman (1978).

6) **The rates of template use and of increases in lexicon size differ across children**.

7) The **relationship between changes in lexicon size and template use also differed** across children.

8) The variable occurrence of the **simultaneous use of multiple templates was observed** across children.

Commentary on the observation in (8) is warranted. Some templates are defined simply by a segment or segment category: H-INIT—word-initial [h], V-INIT—word initial vowel, AE—found in various positions. Others are defined by a sequence of segments across a word's shape. Ultimately, a child's capacity for accurately producing words that are phonologically and articulatorily complex improves over the course of development. Templates for some children interact readily and productively. It could be said that partially established patterns are susceptible to the influence of other sounds and patterns to varying degrees. The phenomenon of multiple-template use was not a major player in the investigation period for Charlotte. Its role was greater among Trevor's and Djuna's data, and was quite notable for E. As such, this phenomenon is variably relevant in the acquisitional paths of different children. For Charlotte, it is possible the investigation period was not extended far enough to see the phenomenon surface. Given that the numerous possible phonotactic patterns in the ambient language become part of the phonological system at some point, it is reasonable to hypothesize that what are initially simple sounds and sound sequences are categorized according to increasingly more complex detail, and begin to interact with each other as a child becomes attuned to the finer details of the ambient language. A close investigation of the acquisition of segmental representation and the balance between it and whole-word representation would shed more nuanced light on the whole system as it develops. This may offer insight on the variation seen in multiple-template use across children. Indeed templates have been reported to have likely emerged from a child's preference for producing a particular segment (Macken, 1979; Oliveira-Guimarães, 2013; Priestly, 1977/2013), and it is hypothesized that segmental knowledge emerges from whole-word templatic representation (Vihman & Croft, 2007).

The observations herein lead to the conclusion that children take measurably different paths toward an adult-like phonological system. The articulatory preferences and capabilities in place at the outset of word production identifiably impact these paths. Djuna shows a preference for a HIGH-LOW V pattern that may be associated with its presence in her name. She exerts effort aiming to articulate *giraffe*, an articulatorily difficult word with an iambic stress pattern that is less common in English than trochaic—perhaps because toy giraffes populate her bedroom and the word shares an initial consonant with her name. Trevor latches on to velar-dominant whole-word patterns in production. Without knowing more about his prelinguistic vocalizations, child-directed input, and other extra-linguistic details, it is difficult to say here precisely why.

Adapted use of the AE template is documented in E's first and second months of word production (ages 0;9 and 0;10), although immediately calling the repeated occurrence of the vowel [æ] in E's utterances a template came with hesitation. Infants produce this sound easily, so it is a curiosity why the sound became a dominant pattern in E's system but not in that of the other children. As described in Chapter 7, confirmation of a pattern as a representational unit may be possible only by tracing the development of its use and identifying adaptation of the pattern to phonetically dissimilar targets. Appealing to the concept of attractors within dynamic systems theory, perhaps E—as do many children—frequently uttered this sound [æ] prelinguistically. Possibly the child's input reinforced his attention to the sound, entrenching it as a pattern, though we cannot know this for certain at present.

Different templates are seen among the data of different children, and some children seem to depend more heavily on template use than others and at different points in their course of language development. In general, it seems to be the case that while template use is strong at the onset of word production, a decrease in template use follows before templatic behavior increases again. This is the scenario for Djuna, Charlotte, and E. Trevor's data, in contrast, do not show template use until the fourth month of word production, and then over the course of the investigation period template use gradually increases. Furthermore, notable increases in template use are sometimes accompanied by equally noteworthy increases in lexicon size, but this is not the case for all children (see Chapter 3). A study incorporating data on accuracy rates and changes in segment inventory, as in prior work (Vihman & Croft, 2007; Vihman & Vihman, 2011), may enhance clarity on this issue.

These points draw attention to the import of having access to numerous factors that may contribute to the development of a preference for a certain sound over others. Diary studies can contribute informative environmental and contextual details. At the onset of word production, the number of utterances is typically quite small, so incipient trends must be followed closely from the outset. As pointed out many times throughout this work, adapted use of a template is considered to mark the construction of a first phonological system (Vihman & Velleman, 2000). The construction of a first phonological system may not be a discontinuous leap in this way—that is, at one point there was no abstract system, and then there was. Rather perhaps we can estimate that a phonological system comes together gradually by degrees in a process of entrenchment and stabilization of articulatory routines held together by attractive force. Dynamic systems theory offers the conceptual framework with which to understand such processes, and schema theory offers a means of breaking down processes into complexly detailed still shots that substantially inform analysis.

9.2.2 Schematic depiction of templatic behavior

This research focuses on the phonological pole of symbolic units, as defined within cognitive grammar. The early phonological acquisition data presented provide clear evidence for schematic structure in developing systems initially based on whole-word representation. As such, schema theory is compatible with the templatic approach and, furthermore, supports templatic analysis by facilitating a definable description of template function in terms of the following:

- how templates become units of variable stability in the abstract system;
- how templates result in variant utterances for a single word;
- how templates elicit phonetically similar utterances across words in a child's repertoire.

Analyzing templatic data within schema theory provides a way to see clear structure in place. It also casts light on how relationships between individual structures (e.g., schemas/templates) might develop and, thus, how schematic networks might emerge in a system built on dynamically changing degrees of abstraction. The hope is that this theory can also capture relationships between templatic and non-templatic representational processes as a child's phonological system becomes more adult-like.

One certain advantage of depicting templates in schematic networks is the resulting capacity to reveal not only that relationships exist between patterns, but also to allow for more investigation of the specific kinds of relationships that are involved. Distinct behaviors can be seen among the data of each of the four children studied:

- *Djuna*: two schemas (SIBILANT and A_I) emerge at different times and then enter into dominant simultaneous use to produce numerous words;
- *Charlotte*: one schema (V-INIT) splits into two related but distinct schemas defined by prosodic shape (VCV, VCVCV);
- *Trevor*: a prominent schema (VVELCV) splits off from a larger schematic pattern (VEL HARM: VELC-V-VELC-(V));
- *E*: two schemas emerge (H-INIT and SIB-FINAL) at different times and then begin to be used together, similar to Djuna's system, but with fewer examples of the two patterns interacting.

Despite there being fewer examples of the two highlighted patterns interacting in E's developing phonological system, E's data are employed in this research to point to the very phenomenon of multiple whole-word patterns used simultaneously to produce a given word. Prevalent among E's data, the phenomenon is seen in a limited way among Djuna's data (minimally with the LAB-VEL and HIGH-LOW V patterns and more so with the SIBILANT and A_I patterns). E's utterances frequently employ two or more established templatic patterns. Carrying the research further into development is important to determine the function of multiple-template use, in particular its role in the advancement of a phonological system and how this role manifests across children.

Distinguishing these evolving patterns depends on the ability to follow utterances along a path as they are produced chronologically. Schema theory introduces to the templatic approach the notion of hierarchical organization based on degrees of abstraction, as a function of the frequency-driven entrenchment of usage patterns. Dynamic systems theory, furthermore, ties the two together by providing a conceptual framework within which to set this hierarchical organization in motion within the real-time processes of language use. As noted throughout this work, within dynamic systems theory these degrees of abstraction can be understood as behavioral configurations varying in stability. Routinized patterns become more stable with use, serving as attractors in the system until the influence of other factors in the system or from the ambient language tip the scales to initiate reorganization.

Dynamic systems theory is a crucial component in the interpretation of templates rendered in schematic structure. Attractors and phase shifts give names to the vacillating stability of behaviors within a system, leading to new organizational states. Discussing phase shifts at micro and macro levels may be informative to this end. For example, a localized phase shift can be seen when Djuna's LAB-VEL schema falls out of use at age 1;1, compared with a phase shift more globally affecting the phonological system when segmental knowledge assumes primacy over whole-word units. It could also be conjectured that mid-level phase shifts occur when a system characterized by a set of templates shifts toward the use of a different set of templates. For example, early on in Djuna's system the LAB-VEL and HIGH-LOW V representations dominate, but later the A_I and SIBILANT patterns rise in prominence. In this view, there could be many layers of interacting processes continuously contributing to semi-stable phases in a developing phonological system.

Returning to the point in development at which the first few utterances are produced, the present data can address controversy concerning the use of analogical or schematic processes in the formation of a novel expression. Langacker (1987) argues against there being substantial difference between the use of schema and the use of analogy. The very fact that acquisition data is in the early process of schematization (Tomasello, 2000) highlights the ongoing, dynamic way in which schematization happens as a language-acquirer processes an increasing number of instances of language use to incorporate into the grammar. This highlights the difficulty in drawing a distinction between the use of schema and analogy for this purpose except in a static environment. As a consequence, the conclusion drawn here is that analogical and schematic processes can be placed on a continuum based on abstraction and are ultimately indistinguishable.

Overall, schema theory serves as an insightful supporting framework for the templatic approach, enriching a view of the continuously evolving organization of developing knowledge in a phonological system. Furthermore, the fact that schematic structure is applicable across linguistic subdisciplines makes available a theoretical platform for addressing structural concerns uniting different, but necessarily related, aspects of language in acquisition.

9.3 Limitations and future directions

This study is a first attempt at crafting a theory uniting a whole-word approach to representation with schema theory, housed within dynamic systems theory, and many questions remain. It will be important to determine what this theory is not able to account for. Investigating the extent of the theory's explanatory power will also be important. It was necessary to limit the amount and scope of data used in this work in order to narrow the focus and attend sufficiently to detail in crafting the schematic networks central to the theory. While this limits the reach of the work, the analysis presented here is a first step that impacts our understanding of phonological acquisition. The theoretical framework developed in this research avails itself to a number of rich possibilities for future work, which are described in this section.

Future work will examine more closely each individual system, engaging in rigorous phonological analysis in order to describe and explain production behavior in connection with specific segments, phonotactic sequences, and positional information. Focusing a study on the phonetic composition of utterances in adapted use of a template will further enrich a view of a developing phonological system, highlighting what segments and phonotactic sequences a child is either avoiding or ignoring at a given point in time.

Research expanding on the present work should also address prosodic concerns, drawing from the literature on prosody in acquisition (Demuth, 1996; Demuth & Fee, 1995; Fikkert, 1994; Gerken, 1996; Kehoe & Stoel-Gammon, 1997; Vihman, 1996). Only sequences of consonant and vowels or specific segments are represented in the schematic illustrations here, in a translation of the templatic patterns identified in the data. How prosodic information is to be represented—and incorporated with segmental patterns—needs to be examined, in particular the notion of a schematic foot instantiated by lower-level schemas.

Furthermore, while the present work offers a richly detailed analysis of early production data, a finer-grained study would provide greater insight. To this end, diary studies accompanied by acoustic analysis of intermittent recordings that target the production of a given sound or set of sounds may enrich a view of a developing schematic network—particularly of individual segments—and its contribution to the larger phonological system. Additionally, incorporating recent findings on early word learning (e.g., Hansen, 2016; Takac et al., 2016), analysis of emerging phonological neighborhood density will open the theory to psycholinguistic testing, generating the potential to more carefully create a map of an emerging phonological system in connection with lexical development.

Another topic for future study concerns how segmental categories emerge from whole-word schemas, expanding on prior work (e.g., Vihman & Vihman, 2011). This likely involves simultaneously following the development of templatic and segmental categories. Both Kristiansen (2006) and Mompeán-González (2004) employ the tools of cognitive grammar to describe phonemic-like categories with members of varying degrees of prototypicality, but this is not discussed in the context of acquisition. With evidence that the early phonological system is built upon whole-word-based units, how this might be modeled to accommodate segmental categories is critical for assessing the utility and applicability of the theory.

Bringing this approach to additional and varied data sets is also important. This will involve extending analysis to larger pools of English-acquiring children and to children acquiring languages of different structural characterization, as well as to children acquiring more than one language. Applying the theory to production in atypically developing populations is also of interest. Extending the present work in this way will enhance our understanding of the scope of variation across children and for assessing in more nuanced detail the ambient-language influence on very early production behavior. The more data that can be analyzed from the challenging period at the onset of word production, the more insightful conclusions can be drawn about processes in early phonological acquisition. Data collected at the onset of word production is, unfortunately, of limited access, particularly for languages other than English.

Determining a theoretical approach that can account both for noisy child data and adult data has long been beleaguered by challenge. The work presented here offers a theoretical framework capable of describing data collected in the transition between prelinguistic vocalizations and first words. While the present work—demonstrating the union of a whole-word approach to phonological representation, schema theory, and dynamic systems theory—focuses only on first words, it is easy to see how the framework developed can extend beyond this point. Cognitive grammar—which uses schema theory—has already been clearly applied to adult language, and dynamic systems theory has been shown to be widely applicable, across language as well as cognitive and motor domains. Once a child's phonological system moves beyond organization primarily based on whole-word templates—which the literature suggests is the case—one can readily envision the schematic architecture shifting to categories defined by smaller units shaped by the integration of prosodic and segmental information. Taking this theory to task by testing from numerous angles and targeting clearly defined phonological phenomena in development will reveal its true efficacy.

This dissertation closely examines data from a particularly challenging period of phonological acquisition at the onset of word production. By offering a richly detailed depiction of emerging relationships between linguistic processes, the current work contributes a theoretical framework within which we are able to make sense of these data. Because only American English data are examined here, data from other languages will prove crucial toward refining the theory constructed in this work. What is clear is that using schema theory to support a templatic framework holds great potential for explaining noisy, early phonological acquisition data.

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Appendix A

Child name	Age of child	Date of birth	Sex	Native language	Exposure to other langs?	Siblings?	Methodological details*	Date of study	Researcher
Djuna	1;0-present (beginning with onset of word production)	09/21/2013	F	American English	no	no	diary study; data collected in a natural setting in a notebook throughout the day, every day, by the child's mother (also this study's researcher), a trained linguist	September 2014 to present	Sara Sowers-Wills
Trevor	0;8-3;1.08 (beginning with babbling)	12/04/1971	M	American English (as spoken in California)	unknown	unknown	diary study; data collected in notebooks at least four days a week covering at least four hours per day by both parents, speech pathologists, who received additional training prior to study	throughout 1970s	A.J. Compton
E	0;6.9-3;9.29 (beginning with babbling)	12/22/1997	M	American English	no (mother is a native American English speaker; father is a	one brother, two years and five months older	diary study; data collected primarily by mother but also by father, both trained	1997-2001	Sharon Inkelas

					native Turkish speaker with native proficiency in English; only English is spoken in the home		phonologists, as often as possible in unstructured sessions during regular family activities		
Charlotte	0;10.12-2;11.22 (beginning with onset of canonical babbling)	10/29/2002	F	American English (assumed; details not known)	unknown	one sibling	longitudinal study; subjects located by informal referral; data collected by video and audio recording in children's homes during natural interactions in which the parents or others in the household were present	2003-2005	Barbara L. Davis

*Each child's development was considered to be normal.

Appendix B

Comprehensive list of Djuna's template use, age 1;0 – 1;4.

Age	# Words	# Utterances	Template	Total templ.	Sel	Adap	% Templ. utterances
1;0	12	28					
			A_I	0	0	0	0.00%
			CONS HARM	3	2	1	10.07%
			HIGH-LOW V	14	10	4	50.00%
			LAB-VEL	7	6	1	25.00%
			NASAL LAB-ALV	0	0	0	0.00%
			SIBILANT	0	0	0	0.00%
1;1	19	37	A_I	0	0	0	0.00%
			CONS HARM	4	0	4	10.81%
			HIGH-LOW V	5	4	1	13.51%
			LAB-VEL	0	0	0	0.00%
			NASAL LAB-ALV	0	0	0	0.00%
			SIBILANT	3	3	0	8.11%
1;2	27	59	A_I	2	1	1	3.39%
			CONS HARM	5	0	5	8.47%
			HIGH-LOW V	0	0	0	0.00%
			LAB-VEL	0	0	0	0.00%
			NASAL LAB-ALV	6	4	2	10.17%
			SIBILANT	0	0	0	0.00%
1;3	40	89	A_I	13	7	6	14.61%
			CONS HARM	1	0	1	1.12%
			HIGH-LOW V	0	0	0	0.00%
			LAB-VEL	1	1	0	1.12%
			NASAL LAB-ALV	4	3	1	4.49%
			SIBILANT	4	1	3	4.49%
1;4	80	193	A_I	14	4	10	7.25%
			CONS HARM	4	0	4	2.07%
			HIGH-LOW V	0	0	0	0.00%
			LAB-VEL	7	6	1	3.63%
			NASAL LAB-ALV	1	0	1	0.52%
			SIBILANT	55	40	15	28.50%
ALL	178	406	A_I	29	12	17	7.14%
			CONS HARM	17	2	15	4.19%
			HIGH-LOW V	19	14	5	3.45%
			LAB-VEL	15	13	2	3.69%
			NASAL LAB-ALV	11	7	4	2.71%
			SIBILANT	62	44	18	15.27%

Comprehensive list of Charlotte's template use, age 1;1 – 1;8 (omitting age 1;2 due to no data).

Age	# Words	# Utterances	Template	Total templ.	Sel	Adap	% Templ. utterances
1;1	2	6	V-INIT	3	3	0	42.86%
			H-INIT	2	0	2	28.57%
			ALV HARM	0	0	0	0.00%
			LAB HARM	0	0	0	0.00%
			VEL HARM	0	0	0	0.00%
			ALV-VEL	0	0	0	0.00%
			LAB-ALV	0	0	0	0.00%
			LAB-VEL	0	0	0	0.00%
			CONS HARM	0	0	0	0.00%
1;3	11	41	V-INIT	13	12	1	31.71%
			H-INIT	0	0	0	0.00%
			ALV HARM	2	0	2	4.88%
			LAB HARM	2	1	1	4.88%
			VEL HARM	0	0	0	0.00%
			ALV-VEL	0	0	0	0.00%
			LAB-ALV	0	0	0	0.00%
			LAB-VEL	0	0	0	0.00%
			CONS HARM	4	1	3	9.76%
1;4	2	23	V-INIT	14	14	0	60.87%
			H-INIT	0	0	0	0.00%
			ALV HARM	1	0	1	4.35%
			LAB HARM	1	1	0	4.35%
			VEL HARM	0	0	0	0.00%
			ALV-VEL	3	2	1	13.04%
			LAB-ALV	0	0	0	0.00%
			LAB-VEL	1	1	0	4.35%
			CONS HARM	2	1	1	8.70%
1;5	3	10	V-INIT	7	7	0	70.00%
			H-INIT	1	0	1	10.00%
			ALV HARM	0	0	0	0.00%
			LAB HARM	0	0	0	0.00%
			VEL HARM	0	0	0	0.00%
			ALV-VEL	0	0	0	0.00%
			LAB-ALV	0	0	0	0.00%
			LAB-VEL	0	0	0	0.00%
			CONS HARM	0	0	0	0.00%
1;6	11	39	V-INIT	19	16	3	48.72%
			H-INIT	0	0	0	0.00%
			ALV HARM	2	1	1	5.13%
			LAB HARM	0	0	0	0.00%

			VEL HARM	2	0	2	5.13%
			ALV-VEL	1	1	0	2.56%
			LAB-ALV	0	0	0	0.00%
			LAB-VEL	3	3	0	7.69%
			CONS HARM	4	1	3	10.26%
1;7	18	66	V-INIT	19	8	11	28.79%
			H-INIT	3	2	1	4.55%
			ALV HARM	3	1	2	4.55%
			LAB HARM	3	2	1	4.55%
			VEL HARM	8	7	1	12.12%
			ALV-VEL	5	0	5	7.58%
			LAB-ALV	0	0	0	0.00%
			LAB-VEL	1	0	1	1.52%
			CONS HARM	14	10	4	21.21%
1;8	33	118	V-INIT	23	11	12	19.49%
			H-INIT	18	10	8	15.25%
			ALV HARM	2	2	0	1.69%
			LAB HARM	2	2	0	1.69%
			VEL HARM	6	6	0	5.08%
			ALV-VEL	3	3	0	2.54%
			LAB-ALV	0	0	0	0.00%
			LAB-VEL	8	7	1	6.78%
			CONS HARM	10	10	0	8.47%
ALL		303	V-INIT	98			32.34%
			H-INIT	24			7.92%
			ALV HARM	10			3.30%
			LAB HARM	8			2.64%
			VEL HARM	16			5.28%
			ALV-VEL	12			3.96%
			LAB-ALV	1			0.33%
			LAB-VEL	12			3.96%
			CONS HARM	34			11.22%

Comprehensive list of Trevor's template use, age 0;11 – 1;3. No template use, age 0;8 – 0;10.

Age	# Words	# Utterances	Template	Total templ.	Sel	Adap	% Templ. utterances
0;8	1	1	n/a				
0;9	2	3	n/a				
0;10	3	3	n/a				
0;11	11	23	SIBILANT	0	0	0	0.00%
			VEL-ALV	1	1	0	0.00%
			LOWV_I	0	0	0	0.00%
			VALV CV	0	0	0	0.00%
			VVELCV	0	0	0	0.00%
			ALV HARM	1	1	0	4.35%
			ALV NAS HARM	5	5	0	21.74%
			LAB HARM	0	0	0	0.00%
			LAB NAS HARM	1	1	0	4.35%
			NASAL HARM	0	0	0	0.00%
			VEL HARM	3	3	0	13.04%
			CONS HARM	10	10	0	43.48%
1;0	17	65	SIBILANT	1	1	0	1.54%
			VEL-ALV	1	1	0	1.54%
			LOWV_I	0	0	0	0.00%
			VALV CV	0	0	0	0.00%
			VVELCV	5	4	1	7.69%
			ALV HARM	4	3	1	6.15%
			ALV NAS HARM	2	2	0	3.08%
			LAB HARM	0	0	0	0.00%
			LAB NAS HARM	2	2	0	3.08%%
			NASAL HARM	4	0	4	6.15%
			VEL HARM	6	2	4	9.23%
			CONS HARM	18	9	9	27.69%
1;1	33	107	SIBILANT	8	6	2	7.48%
			VEL-ALV	5	5	0	4.67%
			LOWV_I	1	0	1	0.93%
			VALV CV	0	0	0	0.00%
			VVELCV	4	2	2	3.74%
			ALV HARM	2	0	2	1.87%
			ALV NAS HARM	3	3	0	2.80%
			LAB HARM	10	7	3	9.35%
			LAB NAS HARM	2	0	2	1.87%
			NASAL HARM	2	0	2	1.87%
			VEL HARM	8	2	6	7.48%
			CONS HARM	27	12	15	25.23%

1;2	13	56	SIBILANT	5	5	0	8.93%
			VEL-ALV	1	0	1	1.79%
			LOWV_I	1	0	1	1.79%
			VALV CV	6	1	5	10.71%
			VVELCV	10	7	3	17.86%
			ALV HARM	4	3	1	7.14%
			ALV NAS HARM	1	1	0	1.79%
			LAB HARM	2	1	1	3.57%
			LAB NAS HARM	1	1	0	1.79%
			NASAL HARM	0	0	0	0.00%
			VEL HARM	9	0	9	16.07%
			CONS HARM	17	6	11	30.36%
1;3	37	109	SIBILANT	2	2	0	1.83%
			VEL-ALV	4	0	4	3.67%
			LOWV_I	11	4	7	10.09%
			VALV CV	4	2	2	3.67%
			VVELCV	21	15	6	19.27%
			ALV HARM	3	0	3	2.75%
			ALV NAS HARM	3	3	0	2.75%
			LAB HARM	7	4	3	6.42%
			LAB NAS HARM	2	0	2	1.83%
			NASAL HARM	2	1	1	1.83%
			VEL HARM	18	3	15	16.51%
			CONS HARM	36	12	24	33.03%
ALL	117	367	SIBILANT	16			4.36%
			VEL-ALV	12			3.27%
			LOWV_I	13			3.54%
			VALV CV	10			2.72%
			VVELCV	35			4.90%
			ALV HARM	14			3.81%
			ALV NAS HARM	14			3.81%
			LAB HARM	19			5.18%
			LAB NAS HARM	8			2.18%
			NASAL HARM	8			2.18%
			VEL HARM	44			11.99%
			CONS HARM	108			29.43%

Comprehensive list of E's template use, age 0;9 – 1;7.

Age	# Words	# Utterances	Template	Total templ.	Sel	Adap	% Templ. utterances
0;9	6	14	Æ	9	7	2	69.23%
			LOW-HIGH V	0	0	0	0.00%
			H-INIT	2	2	0	15.38%
			SIB-FINAL	0	0	0	0.00%
			LAB HARM	0	0	0	0.00%
			SIB HARM	0	0	0	0.00%
			NAS HARM	1	1	0	7.69%
			CONS HARM	1	1	0	7.69%
0;10	2	3	Æ	3	0	3	100.00%
			LOW-HIGH V	0	0	0	0.00%
			H-INIT	0	0	0	0.00%
			SIB-FINAL	0	0	0	0.00%
			LAB HARM	0	0	0	0.00%
			SIB HARM	0	0	0	0.00%
			NAS HARM	1	1	0	33.33%
			CONS HARM	1	1	0	33.33%
0;11	5	7	Æ	2	2	0	28.57%
			LOW-HIGH V	4	2	2	57.14%
			H-INIT	1	1	0	14.29%
			SIB-FINAL	0	0	0	0.00%
			LAB HARM	2	2	0	28.57%
			SIB HARM	0	0	0	0.00%
			NAS HARM	0	0	0	0.00%
			CONS HARM	3	3	0	42.86%
1;0	2	10	Æ	3	3	0	30.00%
			LOW-HIGH V	1	1	0	10.00%
			H-INIT	0	0	0	0.00%
			SIB-FINAL	1	0	1	10.00%
			LAB HARM	0	0	0	0.00%
			SIB HARM	0	0	0	0.00%
			NAS HARM	0	0	0	0.00%
			CONS HARM	4	2	2	40.00%
1;1	2	8	Æ	1	0	1	12.50%
			LOW-HIGH V	0	0	0	0.00%
			H-INIT	0	0	0	0.00%
			SIB-FINAL	2	2	0	25.00%
			LAB HARM	0	0	0	0.00%
			SIB HARM	0	0	0	0.00%
			NAS HARM	3	0	3	37.50%
			CONS HARM	3	0	3	37.50%

1;2	8	20	Æ	7	3	4	35.00%
			LOW-HIGH V	6	2	4	30.00%
			H-INIT	1	1	0	5.00%
			SIB-FINAL	0	0	0	0.00%
			LAB HARM	0	0	0	0.00%
			SIB HARM	0	0	0	0.00%
			NAS HARM	3	0	3	15.00%
			CONS HARM	8	1	7	40.00%
1;3	6	14	Æ	2	1	1	14.29%
			LOW-HIGH V	2	0	2	14.29%
			H-INIT	4	2	2	28.57%
			SIB-FINAL	3	3	0	21.43%
			LAB HARM	0	0	0	0.00%
			SIB HARM	0	0	0	0.00%
			NAS HARM	1	0	1	7.14%
			CONS HARM	1	0	1	7.14%
1;4	11	28	Æ	3	1	2	10.71%
			LOW-HIGH V	4	2	2	14.29%
			H-INIT	3	1	2	10.71%
			SIB-FINAL	6	6	0	21.43%
			LAB HARM	0	0	0	0.00%
			SIB HARM	3	1	2	10.71%
			NAS HARM	3	0	3	10.71%
			CONS HARM	11	3	8	39.29%
1;5	20	40	Æ	5	4	1	12.50%
			LOW-HIGH V	12	5	7	30.00%
			H-INIT	6	2	4	15.00%
			SIB-FINAL	5	5	0	12.50%
			LAB HARM	3	2	1	5.00%
			SIB HARM	0	0	0	0.00%
			NAS HARM	3	2	1	7.50%
			CONS HARM	9	5	4	22.50%
1;6	20	45	Æ	6	4	2	13.33%
			LOW-HIGH V	10	4	6	22.22%
			H-INIT	8	2	6	17.78%
			SIB-FINAL	8	7	1	17.78%
			LAB HARM	1	0	1	0.02%
			SIB HARM	2	1	1	4.44%
			NAS HARM	5	4	1	11.11%
			CONS HARM	10	5	5	22.22%

1;7	51	95	Æ	12	10	2	12.63%
			LOW-HIGH V	18	9	9	18.95%
			H-INIT	15	8	7	15.79%
			SIB-FINAL	14	14	0	14.74%
			LAB HARM	7	7	0	7.37%
			SIB HARM	2	2	0	2.11%
			NAS HARM	1	0	1	1.05%
			CONS HARM	16	12	4	16.84%
ALL		284	Æ	53			18.66%
			LOW-HIGH V	57			20.07%
			H-INIT	40			14.08%
			SIB-FINAL	39			13.73%
			LAB HARM	13			4.58%
			SIB HARM	7			2.46%
			NAS HARM	21			7.39%
			CONS HARM	62			21.83%

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PUBLICATIONS

LINGUISTICS

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POETRY

2010 *The Ocean Arrives*, a collaborative chapbook composed of my poems and artwork and design by Ben Peterson

2010 "The Kangaroo's Song, or There's a Lot Going on with Nothing Going On," a short story included in the print product for a project examining perspective and perception through the use of video, photography, the written word, and book design, conducted by the artist Ben Peterson

2007 "Vertigo", *Journal of the New Jersey Neuroscience Institute*

2006 "Violet in the Wake", *Sleep Medicine*

2005 "Infatuation" and "The Apple", *Denver Quarterly*

2004 “It Made Perfect Sense” and “Brass Tacks”, *around*

2003 “After the War”, *Pleiades*

2002 “Is You Is or Is You Ain’t” and “A Family Takes Shape”, *Interim*

PRESENTATIONS

LINGUISTICS

May 24, 2017 53rd Meeting of the Annual Chicago Linguistic Society
Workshop on Dynamic Modeling in Phonetics and Phonology
“Templates and Dynamic Systems Theory in Early Phonological Development”

Oct 10, 2015 5th Annual Linguistics Alumni Weekend, Bloomington, IN
“The Template in Phonological Acquisition: Evidence from a Diary Study”

Sept 12, 2015 20th Midcontinental Workshop on Phonetics and Phonology, Bloomington, IN
“The Template in Phonological Acquisition: Preliminary Data from a Diary Study”

April 3, 2015 9th Annual IU Linguistics Department Graduate Student Conference, Bloomington, IN
“Templates in Early Phonological Acquisition: A Diary Study”

POETRY

2004 Raritan Valley Community College Spring Colloquium, Branchburg, NJ
“Knowing Thyself from the Outside In”, a philosophy of teaching creative writing

HONORS AND AWARDS

2017 Daniel A. Dinnsen Excellence-in-Teaching Award (Associate Instructor for L103 Introduction to the Study of Language)

2015 College of Arts and Sciences Dissertation Completion Fellowship, for the Academic Year 2016-2017

2015	Fred W. Householder Award winner for outstanding graduate student paper "An Overview of the Template in the Work of Marilyn Vihman and a Preliminary Templatic Analysis of Data from a Diary Study"
2015	Fred W. Householder Award runner-up for outstanding graduate student paper "Using Corpus Data to Examine Collocational Patterns, Lexicographic Representation, and the Nature of Near-Synonymy"
2014	Foreign Language and Area Studies fellowship, first-year Hungarian, summer
2013	Foreign Language and Area Studies fellowship, second-year Turkish, summer

PROFESSIONAL EXPERIENCE

2001 – Present	FREELANCE EDITOR Copyedit work by authors in diverse industries, covering many styles and subjects, including academic articles, dissertations, clinical reports, literary translations, and spiritual monographs.
2015	RESEARCH ASSISTANT (AUGUST – DECEMBER) Designed, wrote for, and edited the Fall 2015 IU Linguistics Department newsletter, while maintaining the departmental web site and calendar.
2015	GRADUATE ASSISTANT (JUNE - JULY) IU Summer Language Workshop. Recorded lectures, maintained the podcast channel, ran the listserv, and assisted with cultural events.
2014 – 2015	GRADUATE ASSISTANT (AUGUST 2014 – MAY 2015) Department of Apparel Merchandising and Interior Design. Assisted Kennon Smith and C. Thomas Mitchell with various jobs, including editing, transcription, and literature reviews.
2012 – 2014	GRADUATE ASSISTANT (AUGUST 2012 – MAY 2014) Department of Near Eastern Languages and Cultures. Organized two guest lectures per year; contributed to the design, writing, and editing of the annual departmental newsletter; and planned and designed publicity materials for small-scale departmental events.
2012 – 2013	RESEARCH ASSISTANT (SEPTEMBER – MAY) Worked with Michael Becker on a project investigating the learnability of opacity and transparency in phonologically conditioned allomorphy, using an artificial language.

2011 – 2013 EDITORIAL ASSISTANT (AUGUST – MAY)
Edited book notices for the electronic version of the journal *Language*.

2011 – 2013 RESEARCH ASSISTANT (AUGUST – MAY)
Edited Cecilia Obeng's academic articles and prepared them for submission to journals, and also edited one of her books.

2007 – 2011 PRODUCTION MANAGER AND REPRINT COORDINATOR / PRODUCTION ASSOCIATE
Managed the production archives and e-book conversions for monthly releases in five imprints; ran cost analyses; coordinated with editors, designers, and printers for the production of reprints and new paperback titles; worked with sales associates for special print projects; managed inventory database; reviewed printer proofs; and trained interns.

2004 – 2007 EDITORIAL ASSISTANT
Managed the flow of manuscripts from submission to publication for the international journal *Sleep Medicine* and the in-house *Journal of the New Jersey Neuroscience Institute*; copyedited accepted manuscripts; conducted correspondence with authors, reviewers, editors, and publishing representatives; contributed to decisions on manuscripts and production; assisted Editor-in-Chief with book projects; and created presentations for lectures on sleep medicine.

LANGUAGES STUDIED

- French
- Latin
- Classical Greek
- Modern Greek
- Turkish
- Hungarian

MEMBERSHIPS AND AFFILIATIONS

- International Association for the Study of Child Language
- International Cognitive Linguistics Association
- Linguistics Society of America